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J. H COLLINS

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A FIRST BOOK

OF

MINING AND QUARRYING

WITH THE SCIENCES CONNECTED THEREWITH

For Use in Primary Schools and Self-Instruction

BY

J. H. COLLINS, F.G.S.
MINING AND METALLURGICAL ENGINEER;
FORMERLY LECTURER TO THE MINERS' ASSOCIATION OF CORNWALL AND DEVON;
AUTHOR OF "A HANDBOOK TO THE MINERALOGY OF CORNWALL
AND DEVON," ETC. ETC.

WITH NUMEROUS ILLUSTRATIONS

Second Edition, Revised, with Additions

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PREFACE.

This little work has been written in order to meet the want, often experienced by teachers of the young in mineral districts, of a book giving a general outline of the characteristic industries of such districts in a simple manner. It is intended much more to show what has to be learnt by the miner and quarryman than to impart actual knowledge; yet it is believed that a good deal of useful information will be found in its pages.

The writer is accustomed to teaching young and often illiterate students, and he has especially aimed at simplicity throughout. He has, however, tried to retain scientific accuracy, and, that the book might not be too long, he has always studied brevity. The work is certainly brief, and if it be found simple and accurate any occasional abruptness or bareness of style will be of little consequence.

It is divided into short chapters, which may very well serve as distinct lessons when the book is used in schools.

The glossary and index are combined for greater convenience of reference, and this part of the work will perhaps be found useful to some students who are neither young nor illiterate.

J. H. C.

NOTE TO THE SECOND EDITION.

In preparing this edition at the request of the Publishers, I have not found much to alter. Some additions, however, have been made, and a new chapter—on "Gold Gravels and Diamond Mines"—has been inserted: but the strictly elementary character of the book has been carefully preserved. It is hoped, therefore, that it may now increasingly find its way as a reading book into the elementary schools of such mining districts as Cornwall, Wales, and Derbyshire, as well as into those of the mining regions of the Colonies and of the United States of America.

J. H. C.

LONDON, *April*, 1888.

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A FIRST BOOK

OF

MINING AND QUARRYING.

CHAPTER I.

INTRODUCTION.

MANY substances of great value to man—such as coal, iron, copper, lead, tin, slate, and building stones, are dug out of the earth. Coal and the metals are usually obtained from deep pits called MINES, which extend far underground in various directions; slate and building stones are mostly got from holes cut in the sides of hills, and open to the day—called QUARRIES. Getting the coal or metal from the mine is called *mining;* digging out the stone from the quarry is called *quarrying.*

In Mining and Quarrying a knowledge of several sciences—such as MECHANICS, CHEMISTRY, MINERALOGY, and GEOLOGY is of great importance. This little book is intended to show, as simply as possible, how these sciences are applied in working the mines and the quarries.

The science of Mechanics teaches us how to move heavy weights, or to raise them from great depths, in the easiest way ; how to keep the mines free from water; and how to supply the men with pure air to breathe while underground.

The metals are generally combined with other substances in the earth, so as to form *metallic ores.* They are also, usually, mixed with waste matter or *vein-stuff* of little or no value.

By means of Chemistry we are able to find out how much the ore is worth when it is raised, and how to separate the metal which it contains from the baser matter, by the process of *smelting.* We also learn, by the aid of this and other branches of science, the great value of *pure air,* and the necessity for good *ventilation,* as the method by which the bad air is removed and healthful air supplied is called.

Neither coal nor the metals are to be found *everywhere,* and we cannot look into the earth so as to see where they are. Besides this, many of the most valuable ores sought for in mines are not at all like the metals they contain. The science of Geology teaches where coal and the metallic ores are most likely to be found, and Mineralogy shows how they may be known when they are found.

The ores of such metals as tin, copper, and lead, are usually found in "*lodes;*" coal is found in "*seams,*" or "*beds;*" iron ores occur sometimes in lodes and sometimes in beds.

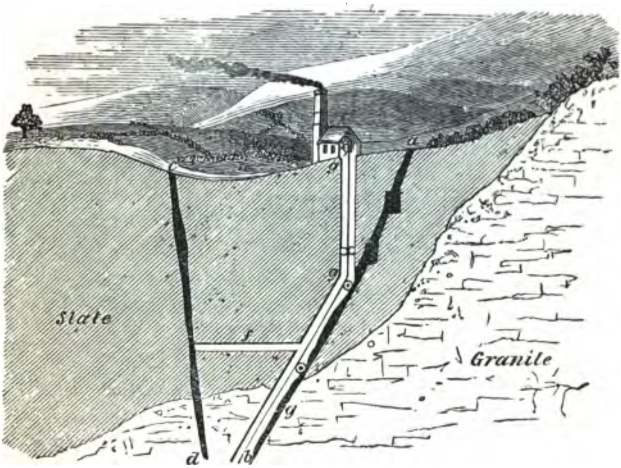

Fig. 1.

a b, a lode underlying to the left. *c d*, a lode underlying to the right. *f*, a cross-cut. *g g g*, shaft, at first perpendicular, afterwards upon the lode.

Lodes are very much like deep cracks in the earth, filled up with *ore* and *vein-stuff.* They are often several miles in length, while their width varies from less than one inch to many feet, and they extend down into the earth to an unknown depth. Fig. 1 shows two such cracks—one with a slope, or "*underlie,*" to the left, or away from the granite, and the other underlying to the right and towards the granite. Fig. 2 is what is called a *longitudinal section*, showing one of the lodes in

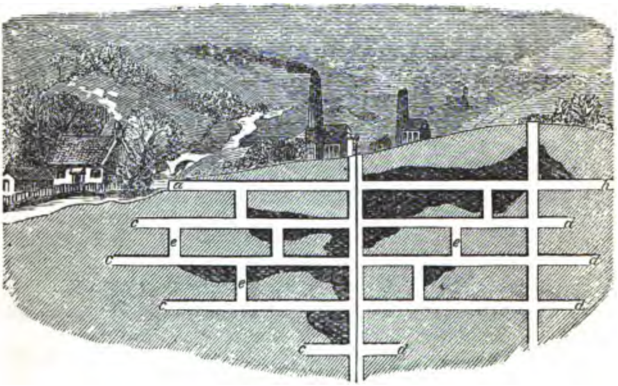

Fig. 2.
a b, adit level. *c d*, *c d*, *c d*, other levels. *e*, *e*, winzes.

Fig. 1, as it would appear if all the country on one side were removed and the observer facing it. It also shows the "workings" of the mine, of which we shall speak presently.

Beds of coal are generally more nearly horizontal and more even in thickness than lodes. They usually occur between layers of different kinds of rock, and when disturbed by "*faults,*" the adjoining rocks are the same on each side. Fig. 3

represents two such seams, *a a* and *b b*, disturbed by a *fault*, *l l*. It will be seen that the beds of rock are the same on each side of the fault, but at different levels, as if all the country on the left had sunk down, or that on the right had been raised.

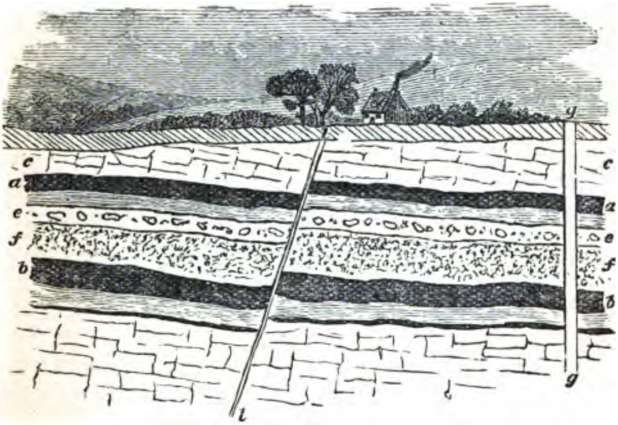

Fig. 3.

a a, *b b*, beds of coal. *c c*, *e e*, *f f*, beds of sandstone, ironstone, clay, &c. *l l*, a fault. *g g*, a shaft.

When a deep hole is dug in the ground, the rain soon soaks in, or runs in, and often fills it up, so that most deep mines require to be *drained.* This is done by pumping out the water as fast as it collects in the bottom. Sometimes the pumps are worked by water-wheels, or by horses, but in large mines generally by one or more powerful steam-engines, which are kept at work day and night. Pumps are seldom required in quarries, as the workings are not often carried deep down into the earth.

CHAPTER II.

HOW METAL MINES ARE WORKED.

THE methods of working a *lode* in a metal mine and a *seam* in a coal mine are so very different that it will be better to describe them in separate chapters. In a metal mine, as soon as the lode is found, which is not always an easy task, a hole is generally dug straight down into the earth, so as to meet the lode after a little, as shown in Fig. 1. This is called "sinking the shaft." As soon as the lode is reached the shaft is carried down upon it, and following its underlie. (See Fig. 1.) Sometimes, however, the shaft goes down upon the lode from the commencement, as shown in Fig. 31, and occasionally it is sunk all the way perpendicularly.

Meanwhile a tunnel is dug leading from the nearest valley or water-course, right into the hill in which the lode is situated (Fig. 2, *a b*), so that all the water from the parts of the mine *above* the level may run away of itself. This is called the *adit level,* or more shortly the adit. Sometimes one large adit is dug so as to carry away the water from the upper parts of many mines by means of branches. The "great adit," as it is called, in the west of Cornwall, is, with its branches, upwards of thirty miles in length, and formerly, when all the mines drained by it were in full work, the water pouring from its mouth formed a not very small river.

Other tunnels are then dug, or, as the miners say, "*driven,*" along the lode about sixty feet below each other, as shown in Fig. 2, and these are called the *levels* of the mine. In descending the shaft, therefore, these levels will be seen as so many low and narrow tunnels, passing away to right and left, and always following the course of the lode. As the levels become extended to great distances from the shaft, smaller shafts, *e e,* called *winzes,* are dug from one to another; these are of great use in assisting the *ventilation* of the far ends of the levels, and in "proving" the value of the neighbouring lode. When a mine has more than one lode, as is very often the case, *cross-cuts* are sometimes driven from one to the other; such a cross-cut is shown at *f,* in Fig. 1. Other shafts are also dug from the surface, from time to time, as may be required.

The lodes in some parts contain very little of the ore sought for, being filled up by vein-stuff of no value, when they are said to be *poor*; at other times, when much ore is found, they are called *rich*. In some mines the lodes, which were rich at first, have been poor for hundreds of feet in depth, and yet have become rich again at greater depths. Others have been abandoned after their owners have lost many thousands of pounds.

When the lode is rich enough to make it worth while, the ore is often dug out completely, as shown in the shaded parts of Fig. 2. Generally, however, in large mines some of the richer portions are left as reserves, to be worked at some future time should the bottom of the mine become poor.

The men are paid for driving the levels and cross-cuts, and for sinking the shafts and winzes, at so much per foot or fathom in length or depth. This is called "*tut-work*." To avoid sending too much of the vein-stuff or waste to the surface with the ore, the parts of the lode between the levels are often removed by *tributers*. These are paid according to the *value* of the ore raised at so much in the £., so that it is their interest to keep the waste separate from the ore. If the lode is *very* rich or even in quality, it is usually removed by tut-work, or else by "*stopers*," who are paid so much per ton. Often the lode, and the rock on each side of it, called the *country* by the miners, is very hard, when the most convenient way of working is to *blast* it with an explosive. To do this a hole is bored in the rock, a quantity of the explosive rammed in, and fired, when large masses are often loosened or thrown down.

In order to blast with safety the men have to get out of the way before the explosion takes place. To give time for this, the gunpowder is now mostly fired by means of a length of *safety-fuse*. The safety-fuse is a twisted cord of hemp or cotton, which has two or three narrow channels, filled with a very combustible composition, running through its whole length. The miners place one end of the piece of fuse in the powder, at the bottom of the hole, leaving the other end projecting outside. This outer end is then lighted by means of a match or candle, and the fuse slowly burns down until it reaches the powder, when the explosion at once takes place. During this time the men go back to a sheltered corner, so as to avoid injury from the shattered fragments of rock. Before the invention of safety-fuse, and even now in some places, the men used straws, or quills placed one within another, and filled with gunpowder, to fire their "shots," as they are termed. These imperfect contrivances sometimes lead to dreadful accidents, from the firing of the powder before the men are removed to a safe place.

To make the explosion as powerful as possible, the upper part of the hole, above the powder and around the fuse, is filled with sand or clay, and rammed down hard. This is called *tamping*, and it is done with a *tamping-bar* of hard wood, or of iron with a copper tip, the bar being heavily struck with a hammer. Many men have been injured for life, or killed, while tamping holes with an iron tamping-bar without a copper tip. These sometimes strike fire when driven against the sides of the hole, and cause the powder to explode before the proper time. Bars of wood or copper do not strike fire with even the hardest rocks, so that this source of danger is got rid of when they are used.

When the levels are long, rails, called *trams*, are often laid down, on which low-wheeled trucks may be pushed along by men or boys, so as to bring the ore and waste to the shaft with greater ease. Similar trams are laid down on the ground at the surface, so that the ore may be readily taken to any required point.

From the mouths of the levels the ore has then to be lifted to the surface up the shaft. This is sometimes done from small depths by means of a *windlass*, Fig. 4, but more often by a *horse-whim*, Fig. 5. In deep mines a large water-wheel, or a

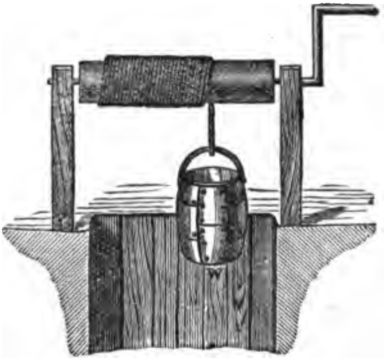

Fig. 4.—A Windlass, or "Taykle."

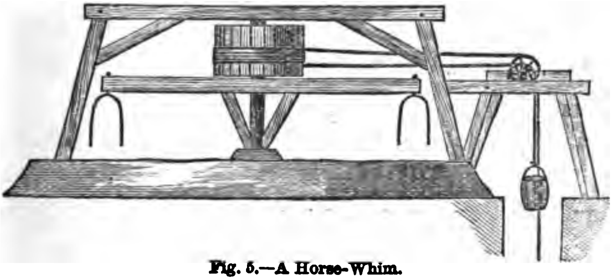

Fig. 5.—A Horse-Whim.

steam-engine, called a *winding-engine*, is used for this purpose.

The ore is raised in large iron buckets, called kibbles, Fig. 6, which sometimes hold a ton at a time, or in *skips*, often holding two tons or more.

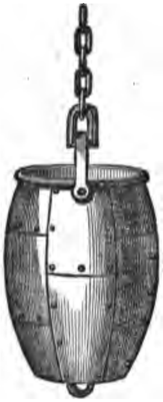

Fig. 6.—A Kibble.

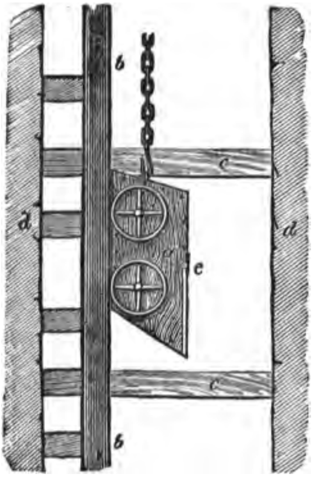

Fig. 7.—A Skip.
a, the skip. *b b*, the guide. *c c*, timbers of the shaft. *d d*, rock through which the shaft is sunk.

The skip, Fig. 7, is a kind of carriage with the lower end of one side hinged like a door. It is made to run on small wheels, against rods of wood or metal, called *guides*, fixed against one side of the shaft. The kibble hangs free, and soon wears out by knocking or rubbing against the sides of the shaft.

Until the last few years, the ore was drawn to the surface by means of ropes made of hemp, or by iron chains. These ropes and chains would often break quite suddenly and without giving any warning. In one instance, where nine men were being pulled up an inclined shaft, seated in a kind of skip, all were dashed to pieces from the sudden breaking of the chain. In many cases ropes made of thin iron or steel wires twisted together are now used, and these "wire ropes," as they are called, are not only much stronger, but much safer than either hempen ropes or iron chains, as they do not break without giving previous warning.

CHAPTER III.

HOW THE ORES ARE PREPARED FOR SALE.

WHEN the ore reaches the surface the larger lumps are picked out and broken up, or *spalled*, by means of large hammers, into pieces of two or three pounds weight. These are then examined, the poorer pieces thrown aside as waste, and the richer fragments placed in heaps by themselves. Tin ores are then conveyed direct to the *stamps*, but copper ores are usually broken still smaller with smaller hammers. This is called *cobbing*. In Cornwall the cobbing, and sometimes the spalling also, is done by women or girls, who sing hymns or plaintive songs while at work; and the singing, together with the clean appearance and curious head-dresses of the workers, form some of the most pleasing and striking peculiarities of the mining districts.

Occasionally the ore from a large lode is of very even quality throughout, when, instead of the cobbing and spalling, the ore is broken up by "stonebreakers" made for the purpose. After this preliminary treatment, copper and lead ores are usually "crushed" between heavy iron rollers, but tin ores are at once carried to the stamps.

These consist of heavy beams of wood or iron, each having a mass of iron, each weighing several hundred weights, fixed upon its lower end, as shown in Fig. 8. The vertical beams are called *lifters*, and the mass of iron at the bottom end is the *head*. These stamps are lifted by projecting pieces of iron called *cams*, which are fixed on the "stamps-axle." This is turned by a water-wheel in small mines, and often by a steam-engine in larger ones, so as to be continually raising the stamps to the height of a foot or less. As the axle revolves the cam slips from under the projecting part of the lifters, when the stamps drop upon the ore and break it in pieces. This succession of blows breaks up the ore into a fine powder

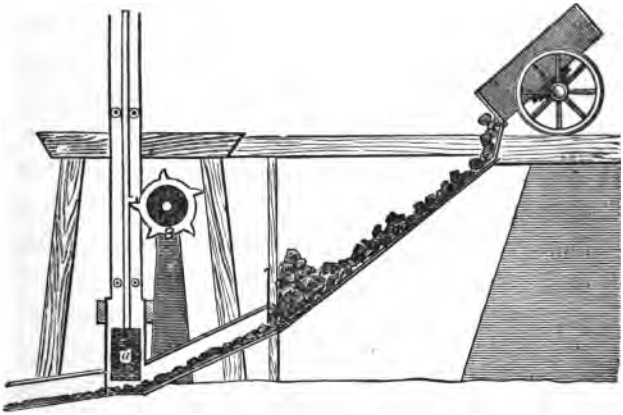

Fig. 8.—Section of a Stamping Mill.
a, the stamps-head. *b*, the stamps-axle.

which is washed away by a stream of water as fast as it is formed to the "dressing-floors." These are sometimes in the open air, but in well-appointed mines they are often covered.

The muddy stream of water and crushed ore is, as soon as it reaches the dressing-floor, run into *pits*, *frames*, or *buddles*, of different kinds, so as to separate the heavy particles of ore from the lighter waste. The buddle most generally in use is a shallow circular pit with a raised centre, from which the bottom slopes gradually away. The ore is conducted by a wooden gutter, or *launder*, into a cup placed in the centre of the buddle, which it soon fills, and runs out over the sides and down the slope towards the outer circle of the pit. At the same time a number of brushes are made to move slowly around the buddle, so as to spread the deposit as equally as possible, and also to prevent the solid particles from settling too quickly. By this treatment it is found that most of the ore, being heavy, settles on the upper part of the slope, near the centre of the buddle, while the lighter waste is carried down towards the outer rim of the buddle, the water flowing away in a channel provided for the purpose.

The *frames* are sloping, oblong, wooden trays, used for dressing ores of different qualities. The ore is here, too, made to run down over the slope, when the richer portions remain on the board, while the waste is carried off by the flow of water.

When the ore is thus rendered tolerably pure, it is placed—several hundred-weights at a time

—in a large tub, called a *kieve,* and well stirred up with water. It is then allowed to settle, while a continued knocking with hammers is kept up against the sides of the kieve the whole time. When at last the ore has all settled down the water is poured away, and the upper surface of the deposit scraped off and put aside. This upper layer contains what little impurity was left in the ore after its various buddlings. This operation is called *tossing* or *tozing.*

By a repetition of such processes as those just described, the tin ore is at last "cleaned" from the waste, or "dressed," and is ready for sale, under the name of *black tin,* although generally a brown or red powder. The principle of all these operations is the same, and it is very simple. When heavy and light materials are agitated with water and allowed to settle, the heavy naturally falls first. As the waste is nearly always much lighter than the ore, such methods as those above described answer very well. In some cases, however, the waste is of a metallic nature, and nearly or quite as heavy as the tin ore. When this is so, it is necessary to change the nature of the waste by some chemical means, such as heating it in a current of air, or "burning" it, as the miners say. Some tin ores contain a portion of iron, combined with *sulphur* or *arsenic*. These always need to be "burnt," so as to make the waste lighter before the dressing is completed.

This burning or calcining is generally done by placing the ore in a thin layer, on a large revolving plate of iron fixed in a furnace. It is now sometimes effected in a better way by means of Oxland and Hocking's "Calciner." This is a tube made of wrought-iron plates, about four feet in diameter and thirty feet long, fixed so as to revolve, and with a little slope from end to end. The ore is put in at the upper end, and as the tube revolves it gradually makes its way downwards to the lower end. The furnace is at the lower end, and the flame and heated air passes up through the tube, roasting the ore as it passes. By the turning of the tube the particles of ore are made to drop continually through the flame and heated air until they reach the lower end, by which time they are thoroughly roasted.

Copper and lead ores, after being "crushed" instead of "stamped," are usually "jigged" instead of being "buddled." In jigging the crushed ore is placed in a kind of sieve, and shaken in water with a peculiar motion, which causes the heavy ore to settle to the bottom, while the waste accumulates near the top, and is scraped off as in "tozing" tin ore. They are occasionally stamped and buddled, but only when other methods cannot be applied, as there is always more waste carried off by the running water than with tin ore. Besides this, neither copper nor lead ores need to be cleaned for sale so completely as those of tin.

When the ores are dressed they are ready for sale to the "smelter," whose work it is to extract the metal from the ore. Here a knowledge of chemistry is necessary, both to enable him to find out the value of the ores before purchasing, and to adopt the best methods of "reducing" them. Whatever the nature of the ores, however, the general principle of the treatment is the same. They are mixed with coal and with various *fluxes*, and then strongly heated, as will be further explained in a future chapter.

The tin from the Cornish mines is all smelted in Cornwall, together with some foreign tin. Lead is smelted near Bristol, in Wales, and in London; but the copper ores are mostly taken to Wales for that purpose. The vessels which take copper ore from Cornwall to Wales usually carry coal back on the return voyage for smelting the tin, and for the use of the Cornish mines. Lead ores generally contain a small proportion of silver, and the Cornish and Devonshire lead ores are more than usually rich in that metal, containing on an average about 33 ounces to the ton of ore. This silver is separated by a distinct process.

The manner of working described in the foregoing chapters applies more especially to cases where the ore sought occurs in veins or lodes. When the ores occur in beds, irregular deposits, or stockworks, it is necessary to modify the manner of working in some particulars.

The ore from veins carrying gold is usually enclosed in quartz. It is stamped finely, just like tin-ore. The "pulp" is then made to pass over copper plates covered with a thin film of mercury or quicksilver. This mercury has a great attraction for gold, and it seizes hold of any particles that may be present while the sand and mud pass on and are so got rid of. From time to time the "*amalgam*" of gold and mercury is "cleaned up," the mercury is distilled off by heating in an iron retort, and the gold is left behind, only needing to be melted into an ingot, when it is ready for sale.

The mercury, however, can only take hold of the gold which is present in the metallic or "free" state. Should it be present in combination with iron pyrites or other "sulphurets," these are separated by "concentration" over "*Frue Vanners*" or other machinery after the pulp has passed over the amalgamating tables. The concentrates are then either sold to the smelter or else the gold is got out of them by roasting, and a subsequent treatment with chlorine gas.

Some silver ores are treated precisely like gold ores, but the process of amalgamation is generally slower and more troublesome.

Mercury itself is got by distilling the mercury ore (cinnabar) in iron or clay retorts, and condensing the vapours so driven off.

In some important copper deposits, the ore is far too poor to pay for smelting. At Rio Tinto these poor ores are roasted in heaps in the open air, by which means a great part of the copper becomes soluble in water. The heaps are then broken down, the roasted ore washed, and the solution of copper thus obtained is made to flow over bars or scraps of iron. The iron is soon dissolved while the copper is precipitated from the solution in the form of small plates or scales, often very beautiful and of great purity.

Ores of arsenic, which are raised in great quantities in East Cornwall and West Devon, are roasted in furnaces, by which means the arsenic is driven off in the form of a dense smoke. This smoke, which consists of a combination of the arsenic with the oxygen of the air, is caught in flues and chambers and sold for glass-making and many other purposes. A great many other methods of ore-treatment are in use, but we have not space to describe them here.

CHAPTER IV.

HOW THE MINERS GO DOWN TO THEIR WORK.

THE miners in most metal mines go to and from their work underground by means of ladders; sometimes, however, they come up in the skip used for raising the ore; and in a few of the larger mines a peculiar contrivance called the "man-engine" is made use of. This relieves the men from that which is often the hardest part of the day's work—climbing up nearly vertical ladders for a quarter or a third of a mile, and often carrying heavy tools, after working all day in bad air and in a cramped position.

The man-engine is a vertical beam of wood called the "rod," which is made to move alternately up and down through a space of twelve feet, by means of a pumping or other engine. On the rod steps are fixed, twelve feet apart, on which the men stand while the rod is in motion, holding on by iron handles provided for that purpose. When it stops its steps are level with little platforms called "sollars," which are fixed in the sides of the shaft. By standing on the steps of the rod only during its upward motion, and on the sollars while it moves downwards, the men are raised to the surface by successive lifts of twelve feet or two fathoms, without any labour on their part beyond stepping from the rod to the sollar and back again. As many men may thus be brought up from their work at one time as there are steps on the rod, and as the sollars are fixed on *both* sides of the shaft, an equal number of men may be carried down at the same time, each stepping on the rod as the man leaving work steps *off*.

The man-engine is so great an advantage to all concerned, both workmen and employers, that it would soon become generally used but for its great expense. This is very great indeed, since most of the shafts in old mines are too narrow, and also too irregular, to admit of its introduction. The cost of the rod itself, and of its fittings, is also very considerable.

To light him while underground, each man carries several candles, which he usually hangs to a button of his coat. A lump of clay serves for a candlestick, and this he places, with the lighted candle in it, on the front of his hat while going down or coming up the shaft. When he reaches his place of work, his "pitch," as he calls it, he takes the candle and clay from his hat and sticks it up against the wall to give him light while he is at work. In some few mines the use of gas has been commenced; but in Cornwall, at least, has been soon given up. The reasons for this are not quite clear, as it is said to be more economical than candles. In many foreign mines, oil lamps are used, and in some, "rock-oil" or petroleum.

Sometimes the men work *singly* in the ends of the levels, but more usually two, three, or four—called in all cases a "pair" or "pare"—agree to work in partnership. These, when the lode is wide, will sometimes all work together; but generally they divide themselves into parties, relieving each other at the expiration of eight hours.

CHAPTER V.

HOW COAL MINES ARE WORKED.

It has been already stated that coal occurs in "beds" or "seams," and not in "lodes." These seams are seldom quite horizontal, and they often "dip" from all directions towards a centre, as shown in Fig. 9, forming what is called a coal-basin.

The seam having been discovered by a careful examination of the country, boring, or other means, the first thing to be done is to sink a shaft as in metal mining. This shaft is usually made very much larger than is necessary in a metal mine; and it is dug, whenever possible, into that part of the seam which is deepest down, or to the bottom of the basin. (See *g*, Fig. 3, p. 5, and *c*, Fig. 9.) This is done so that the trucks loaded with coal may *descend* from the far end of the levels to the bottom of the shaft by their own weight. The same shafts serve for all the beds of coal, when there is more than one to be worked, these being almost always parallel to each other.

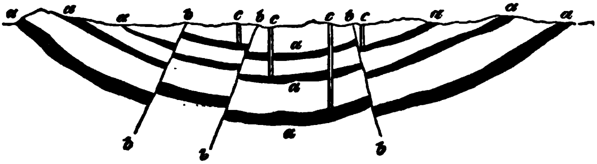

Fig. 9.—A Coal Basin with three seams of Coal, *a a a*, disturbed by three faults, *b b b*. Shafts are shown at *c c c*.

In some metal mines the rock through which the shaft is dug is so hard and solid, that very little needs to be done to protect the sides. In coal mines this is not often the case, especially as the shafts are so much larger. Some shafts are lined with timber, others with brickwork; and in very many modern coal mines, especially where some of the strata are charged with water, with plates of cast-iron. This lining is called "tubbing;" and it is necessary, not only to keep the sides of the shaft from falling in, but also to prevent the mine from being flooded with water, which flows in large quantities from some of the beds of rock cut through.

The beds of coal differ very much in thickness, many being only a few inches, or even less than that; such thin seams cannot be worked without loss. Those seams that *are* worked differ in thickness from about one to thirty feet.

The shaft is sunk for some depth below the level of the workings, as it is in metal mines, so as to form a "sump" for the collection of the water to be pumped out. A large mass of coal is left around the bottom of the shaft, called the "shaft-pillar." Through this shaft-pillar narrow passages, called "drifts," are cut in the directions of the masses of coal to be removed. The drifts at some distance from the shaft are enlarged into galleries about ten feet wide, walls of coal from six to ten yards thick being left between them.

The walls of coal are pierced through in places, as may be necessary for the ventilation of the mine. This is often much neglected in metal mines, but *must* be attended to in coal mines, because of the inflammable gas, called "fire-damp," which is often given off by the coal in large quantities. If this gas were not continually withdrawn it would gather in the workings; and even if it did not explode, the mine would soon be stopped, from the men being unable to breathe.

The galleries are generally timbered on all sides, to prevent them from being forced in by the great weight of the rocks above. A common method of doing this is shown in Fig. 10. Sometimes they are lined with brick or stone, especially where they are made of extra width for the convenience of passing, loading, &c.

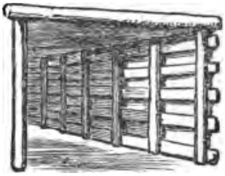
Fig. 10.—Timbering.

Generally the coal is cut out in blocks as large as possible, by means of double-headed picks. It is seldom blasted, not only on account of the great danger from explosions of fire-damp, but also because the concussion would too much fracture the coal. Blasting is, however, often resorted to in first sinking the shaft. In some mines the coal is now cut by means of coal-cutting machines.

The mines are worked by several distinct methods, the chief of which are called the *post-and-stall* and the *long-wall* methods. In the post-and-stall method the coal is cut out in many parallel "levels," "galleries," or "bords," separated from each other by thick walls of coal left standing. These again are crossed by similar levels at right angles, so as to leave great square pillars of coal to support the roof. At one time these pillars were left only a few yards thick, when they soon became so crushed by the weight of the roof as to be quite useless for support. They are now left, in deep collieries, as much as thirty yards by forty yards, only about a quarter of the coal being removed in the first instance.

When these different sets of levels have reached the boundary of the mine, the next operation is to remove the pillars, and this is begun at the far end of the levels or *bords*. The roof is supported by wooden props while the pillars are being removed, and the props are taken out by the men last of all as they work back towards the shaft. This is a work of danger, as the roof sometimes falls in upon the men while they are removing the props. The danger is often increased by their own recklessness in working with the props too far apart.

The part from which the pillars have been taken out is called the *goaf* or *gob*, and this of course is in communication with that part which has the pillars still standing. In this goaf the *fire-damp*, an explosive gas given off by the coal, collects in large quantity, and is a source of most disastrous explosions. To guard against these as much as possible *safety-lamps* have been introduced. These will be described in a future chapter.

The long-wall method of working is sometimes carried out by commencing at once near the shaft-pillar to work away the whole of the coal, leaving only *goaf* or *gob* behind, and supporting the necessary roads through this by masonry. At other times the roads are at once driven out to the boundary, and the coal worked backwards towards the shaft-pillar. The various modifications of the long-wall method are much approved, and used in many of the largest and deepest collieries in the North of England.

CHAPTER VI.

HOW THE COAL IS BROUGHT TO SURFACE, ETC.

THE coal, when dug, is generally at once loaded into *waggons*, *trollies*, or *tubs*, and pushed along on rails, or "trammed" to the bottom of the shaft. This is called *putting* the coal, and it is done by boys, ponies, horses, or in some cases by steam-engines. Such work was formerly done by women, but this degrading occupation is now forbidden by act of parliament. When the shaft has been sunk at the deepest part of the seam, the tubs come down hill by their own weight, pulling back the empty tubs at the same time. Sometimes the coal is reloaded from the tubs to the *cage* or *skip* at the bottom of the pit; but very often one, two, or more tubs are run directly into the cage, and raised at once to the surface, as shown in Fig. 11.

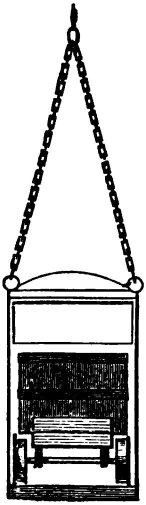
Fig. 11.—Cage with tub for raising coal.

In very small collieries the coal is raised by a *horse-gin*, much like the *whim*, Fig. 5, used in the metal mines of Cornwall; but in all large mines a powerful steam-engine is used, with flat ropes of hemp, called *bands*—flat chains of several links side by side; or wire-rope, flat or round, several inches broad or thick.

The cage is raisedvery rapidly. In some mines, upwards of 300 fathoms deep, the time is little over a minute and a quarter, and the speed in "middle passage" is at the rate of 60 miles an hour.

In coal mines the men are always raised from the pit in the same cages which are used to raise the coal, and often at the same time; neither *man-engines* nor *ladder-ways* being provided. Some very serious accidents have occurred from the engine drawing the cage so high as to force it against the pulley and to break the rope. This is called *over-winding.* To guard against such accidents several contrivances attached to the engine have been devised so as to warn the engine-man. Several kinds of safety-cages have also been invented, with arrangements called brakes, for preventing the cage from falling to the bottom in case of the rope being broken.

Many of the older mines have but one shaft, which is divided into two or three by a *brattice.* This is a partition reaching from top to bottom of the pit. It is often made of wood. The reason for dividing the shaft is to get an up and down current of air for ventilation, and the up-current is produced by a large fire which is kept burning at the bottom of the shaft. Dreadful accidents have arisen from the destruction of the brattices by their taking fire, by the heavy beam of the engine or other heavy weight falling upon them and breaking them down, and from other causes. By act of parliament all collieries are now required to have at least two shafts.

Temporary brattices have to be put up under ground to guide the currents of air. These are often made of "brattice-cloth," a coarse, stout kind of canvas, which is made in large quantities for the purpose.

We have said in a former chapter that iron ores occur sometimes in lodes and sometimes in beds. The lodes are worked like any other lodes unless they are *very* wide, when they are often worked as "open quarries." Some of the iron lodes of Cornwall are several fathoms in width; and one which comes to the coast, in the parish of Perranzabuloe, is seen in the cliff nearly ten fathoms wide; farther inland it is wider still.

Iron ore often occurs in beds between the beds of coal, when it is worked in the same manner as the coal; and the same shaft serves for raising both the coal and the iron ore. The iron is, too, often smelted upon or near the spot, so that the occurrence of the coal and iron ores so near together is a great advantage. Iron is sold at so low a price, and so large a quantity of coal is used in extracting it from its ore, that very often it will not pay to carry either the coal or the ore to a distance.

The dressing processes, which are of so much importance in the preparation of copper or tin ores for the market, are not required for iron ores. These are rarely worked at all unless sufficiently free from foreign matter to allow of being at once smelted. They are sometimes picked over a little by hand, and the inferior pieces cast aside, but nothing more is done by way of preparation.

CHAPTER VII.

GOLD GRAVELS AND DIAMOND MINES.

Many of the most valuable minerals are obtained, not from regular veins or beds, such as are described in the foregoing chapters, but from beds of sand and gravel—from ancient conglomerates and breccias—or from irregular masses of rock which are everywhere sprinkled (impregnated) with particles of valuable mineral substances. The following examples will serve as illustrations.

GOLD SANDS AND GRAVELS.—In many countries the river sands—worn from the mountains from which the rivers flow—are found to contain small scales or minute grains of gold. Sometimes these particles are so few that it does not pay to wash them out of the sand in which they are found. This is generally the case in old countries where the richest portions of the sands have long been washed away; but in countries which have been recently occupied by so-called civilized peoples, such as British Columbia and California, the river sands have often proved much more rich in gold, and very large quantities have been obtained by diligently washing them. Some, as the Fraser River in British Columbia, still yield considerable quantities of gold to small parties of Chinese, Indians, and white men, but a great deal more is obtained by washing the more ancient gravel deposits in the same countries—deposits which were formed either by the existing rivers in old times when they were much larger than at present, or by still older rivers which have now entirely disappeared.

The most profitable way of working such

deposits is by what is called hydraulic mining. This can only be carried on where a large supply of water is available The water is brought in a ditch or in pipes, sometimes for several miles, and when it has nearly reached the gravel it is made to issue with great force through a narrow nozzle, somewhat like that used for a fire-engine. In this way the gravel is rapidly washed down upon a kind of grating, called a grizzly, thus separating the large boulders from the finer gravel, sand, and mud. If the water is abundant and the situation favourable for working, even the boulders may be washed away by a fresh stream of water into a river; but in any case the finer materials are so carried away. It is this finer material, however, which contains the gold, in very fine particles for the most part. This is separated by making the sands flow through channels in which mercury is placed, which takes hold of the gold and secures it as described in a former chapter.

It is remarkable how very little gold can be made to pay by this mode of working where the conditions are favourable. In California, for example, instances are known where "dirt," as the gravel is called, which only contained about threepennyworth of gold in each cubic yard, has been profitably worked.

The quantity of water used is very large, in some instances as much as ten or even fifteen times the weight of the gravel removed being required. It is important also that the water should be obtainable from a higher level, from 50 up to 300 feet being desirable, so that the water may issue from the nozzle with extreme force, especially where the gravel is hardened into what is known as "cement." It is essential, too, that the material washed away should have a convenient place to rest in—a lake bottom, a deep river bed, or an arm of the sea. In the greater part of California hydraulic mining has been forbidden by law, either because the waters hitherto used are required for agriculture, or else because the materials washed away are too much filling up the riverbeds, or are covering the lands of the farmers or the stock raisers.

Where such "auriferous gravels" are covered with later deposits not containing gold the mode of working is much less simple, and they can only be worked if much richer. In such cases they are either worked by removing first the upper covering deposits and then washing away the "pay dirt," or else the pay dirt is mined as if it were an ordinary "bed," pretty much as coal is worked, for instance.

Tin Gravels occur under circumstances precisely similar to gold gravels, and they are worked in the same manner, except that mercury cannot be used to secure the finer grains. Tin ore occurring in gravel deposits is known as "stream-tin."

Diamond Gravels have long been worked in Brazil. The gravel is washed pretty much in the same way as tin gravel, only the very finest material, which in tin and gold gravels is usually the richest, is thrown away, and the grains from the size of a mustard seed up to that of a walnut are carefully examined by the workers after a very rude "dressing" operation.

All such gravel deposits, whether of tin, gold, or diamonds, are called "placers."

The most valuable diamond-fields in the world are those discovered about twenty years ago in South Africa.

CHAPTER VIII.

HOW QUARRIES ARE WORKED.

The workings of metal mines and coal mines are usually far under ground, and only in communication with the open air by one or more shafts, so that some means of withdrawing the spent or foul air, and of supplying the men with fresh air to breathe, has to be devised. This is called the ventilation of the mine. In quarries no such contrivance is necessary, as they are simply holes cut in the sides of hills, and open to the air.

In opening a quarry it is important to secure a good road for the easy removal of the stone, and a simple method of draining without pumping. The stone is very seldom good quite up to the surface of the ground, being generally much broken and discoloured, and covered with a considerable thickness of loose fragments and soil. This is called the "over-burden," and it is sometimes difficult to get rid of it without the expenditure of a great deal of labour. Some good quarries have had to be abandoned from the great accumulation of over-burden, and the heavy expense of removing it.

With different kinds of stone the method of working the quarry is very different. Some rocks are "soft" and "compact," such as "freestone;" others are "hard" and "compact," such as "limestone;" some occur in "thick," others in "thin" layers, as the different kinds of "flagstones" and "slates." Some are worked for building purposes, when it is often desirable to keep the blocks as large as possible; others, which are to be used for mending the roads, or for burning into lime, must be broken up small before they can be used.

In all quarries, whether of granite, limestone, slate, or any other material, cracks are found, passing more or less regularly through the rocks in certain directions; these are called "joints." In granite, hard limestone, and other massive rocks, these joints, which cross the beds in two directions, with the beds themselves, sometimes divide the rocks into masses of tolerably equal size and shape, either "cubes" or "rhomboids."

These joints are often of much assistance to the quarrymen, enabling them to get out the stone with much ease. In some cases the blocks of stone may be got out by simply introducing long bars of iron, called "crowbars," into the joints, and using them as "levers." Very often, however, blasting has to be resorted to, as in mines.

The bore-holes for quarry-blasts are usually much larger than for mining, being in some cases as much as five inches or six inches in diameter, and twenty feet deep. For such a large hole a charge of fifty or sixty pounds of gunpowder, or even much more, is often used. With such blasts very large quantities of rock are loosened or brought down at once.

Of course such deep holes cannot be bored by the ordinary hammer and borer used in mines. Much larger tools, called "jumpers," are used for these, one man holding the jumper, and turning it a little between each blow, while two or three men strike in turn with heavy hammers. Sometimes, when the holes are to be bored vertically, and not very deep, an iron "churn jumper," from seven to eight feet long, with a steel "bit" at each end, is used, being lifted and turned by one or two men, and allowed to fall by its own weight. Smaller jumpers often have a lump of iron forged on in the middle, so as to increase the weight. The larger blocks are often split up into smaller masses by the aid of these small jumpers, or by short iron wedges, which are struck with hammers, after being placed in shallow holes bored for the purpose. Sometimes water is allowed to find its way between the laminæ of the stone, and when this freezes the stone is split very effectually.

The blocks of stone are loaded direct from the quarry into carts or railway trucks by means of a "crane," whenever possible, see Fig. 12. With such a machine two men can raise, but only very slowly, a weight of several tons. The principle of this apparent gain of power will be explained in a future chapter.

The principal kinds of stone quarried for building and ornamental purposes are—granite, slate, sandstone, limestone, dolomite, porphyry, serpentine, gypsum, apatite, and marble. For making into lime, besides limestone, large quantities of chalk are quarried in the east and south of England. For mending the roads, granite, greenstone, basalt, and porphyry are preferred; but when these are wanting, hard limestone, flint, or flint gravel are very often used. In some large districts no hard stones are to be found, when the roads are usually soft and bad, especially in winter. For the paving of the roads in large towns stone is sometimes brought from great distances; thus the streets of London are paved with blocks and fragments of hard granite brought from Leicester-

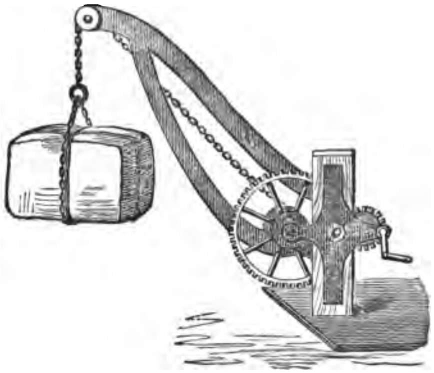

Fig. 12.—A Crane.

shire, Scotland, and Guernsey, and with flagstones from Yorkshire and Lancashire.

Clay is either dug out of open quarries (called clay pits) or else is washed out and allowed to settle in tanks, from which it it is afterwards removed and dried. In this way the famous *china clay* of the West of England is freed from the grains of quartz and mica which occur with it in the ground, and is made fit for exportation and for use in the potteries, paper mills, bleach factories, and chemical works, where it is so largel used.

Besides the various kind sof stone mention above, the more valuable minerals are sometim obtained by open quarrying. Thus at Mulbe Hill and other places in Cornwall tin ore oc in an immense number of thin interlacing v, permeating the whole mass of the rock for n yards in width. To obtain this tin it is nece to break down the rock as a whole and to h and dress the whole mass. Such depos interlacing veins are called "stockworks." es of a somewhat similar character are met in Rhenish Prussia, where thick beds of sa and of limestone occur full of little lumps ore which can only be separated by trea rock as a whole.

In Cheshire beds of sandstone slightly permeated with carbonate of copper have been known for many years, and worked whenever copper was sufficiently high in price to pay expenses.

In the preceding chapter reference is made to what might be called the South African diamond quarries. Here the diamonds are found in a dark blue conglomerate or breccia, which seems to fill the throats of ancient volcanoes. This "blue ground" is dug out from enormous pits and exposed to the air till somewhat softened; it is then broken up, sorted into different sizes by revolving sieves, the lighter stones removed by a kind of "dressing," and the heavy residue carefully picked over by the hand. The working of these great pits is rather quarry-working than mining proper, but they are extended to much more considerable depths than is the case with ordinary quarries, owing of course to the valuable nature of the material worked. Since the discovery of these South African diamond fields, which are altogether but a few square miles in area, about *six tons* of these valuable gems have been obtained from the different mines, and the yearly output seems to be constantly increasing.

CHAPTER IX.

OF MECHANICS.

The study of the machines used in the various modes of mining and quarrying already described, such as the "crowbar" or "lever," the "windlass," and the "steam-engine," belongs to the science of "Mechanics." To understand the action of these machines, we must first learn the meaning of such terms as "matter," "inertia," "force," and a few others.

By the term matter we include everything that can be weighed or measured. It occurs in three states or conditions, as "solid," "liquid," or "gas." The same substance may at different times be in each of these three states, which seem to depend upon the amount of heat in the substance. Thus "liquid" water, by losing heat, or becoming cooler, is converted into "solid" ice; by receiving heat, or becoming hotter, as when it is boiled in a tea-kettle or steam-boiler, it is converted into an invisible "vapour" or "gas," called steam. The science of mechanics is concerned with all three states of matter. That part of it which deals with liquids is called "Hydraulics," and that which treats of gases is called "Pneumatics."

A stone resting upon the ground has of itself no power to move. If it be set in motion, however, it has no power of itself to stop. This property is called "inertia." The first of these statements is very evident, but the second is not so plain. It may be illustrated in the following manner:—Suppose a boy, by using all his strength, is able to roll a ball along a level, grassy field for a distance of one hundred feet before it stops. If the ground were hard and smooth, instead of being covered with grass, the same boy could probably roll the ball two hundred feet; by using the same amount of force on a smooth sheet of ice it would perhaps roll as much as three hundred or four hundred feet. It might at first be supposed that the ball would stop of itself, but this is not so. It stops because it rubs against the ground and because of the resistance of the air. It goes farther on the hard, smooth ground than on the grass, because the rubbing or *friction* is not so great; and that on the ice is less again. There is still, however, *some* friction against the ice, and there is also the resistance of the air, which any one may feel by waving his hand rapidly about. and these resistances at last bring the ball to rest. If the ball be thrown through the air without touching the ice, it will go much farther than before; and if the wind should happen to be blowing in the same direction as the ball is thrown, and just as fast as the ball moves, it will go on to a very great distance. It would, indeed, in such circumstances, keep on moving for ever but for what is called "gravitation," by which it is continually pulled towards the earth. Of course, as soon as it reaches the earth there is friction against its surface, and this brings the ball to rest. This illustration is sufficient to show what is meant by inertia.

All kinds of matter are continually being drawn towards the centre of the earth by a force called gravitation. Thus the kibble shown in Fig. 4, although quite still, is all the while continually pulled downwards towards the earth. When the kibble is empty, a thin chain will hold it, but if full a stronger chain is necessary, because the pull is stronger, or, as we say, the "weight" is greater—that is, the chain will have to bear the pull of the earth on the contents of the kibble, as well as that on the kibble itself. Some substances are pulled much more strongly than others; thus a kibble full of water does not weigh so much as a kibble full of tin ore.

Supposing a substance to weigh six times as much as an equal bulk of water, its "relative weight" or "specific gravity" is said to be 6; if seven and a half times, its specific gravity would be 7·5—water being in all cases the standard of comparison for solids and liquids.

It should be observed that the weight of bodies is sustained by the solid earth. Thus, in the Fig. 4, the weight of the kibble is borne by the chain; this is supported by the axle, and this again by the uprights, which rest upon the ground.

Force is that which tends to move a body at rest, or to alter the motion of a body in motion. It is often called "power" when applied to move bodies, and "resistance" when used to stop or support them. It is a common error to suppose that machines will *create* power. This is not so, but they enable us to apply such power as we have in a convenient manner. Suppose a man is just strong enough to lift a weight of 100 lbs., and place it on a bench 3 ft. high, and that it takes him exactly one second to do it. Suppose, further, that he has to lift a weight of 1,000 lbs. on to the same bench. He might do this by means of a windlass, but not in the same time as he could lift 100 lbs. by his hands alone. The best machine that could be made would not enable him to do it in less than ten seconds, which is just the time it would take him to lift it, supposing it could be first divided into ten equal parts of 100 lbs. each. There is here, therefore, no absolute *gain* of power, since "what is gained in power is lost in speed;" but there is a gain in convenience, since it might be undesirable or difficult to divide the 1,000 lbs. weight into smaller weights.

Again, suppose he desired to raise the weight of 100 lbs. to a height of 30 ft.; without machinery he could not do this except by many distinct lifts, and then only by making use of many separate stages to stand upon. By means of a pulley, however, and a rope, he may raise the weight to the whole height with perfect ease, and without moving from his place.

CHAPTER X.

OF THE MECHANICAL POWERS.

THERE are three simple forms of machinery from which all machines are made up. These are often called the "mechanical powers." They are the "lever," the "pulley" or "cord," and the "inclined plane." Three other "secondary powers" are formed from these; the "wheel and axle" is a kind of perpetual lever, the "wedge" is a double inclined plane, and the "screw" is a perpetual inclined plane, which is generally combined with some form of lever when used.

Any stiff rod which is movable about a fixed point is termed a lever; the fixed point is called the "fulcrum." Levers are generally divided into three classes, according to the situation of the "fulcrum," the "power," and the "weight."

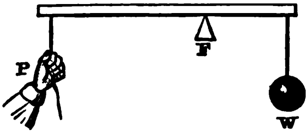

Fig. 13.
P is the power, F the fulcrum, and W the weight.

When the fulcrum is between the power and the weight, as in Fig. 13, the lever is of the first kind. Fig. 14 is another example. When the

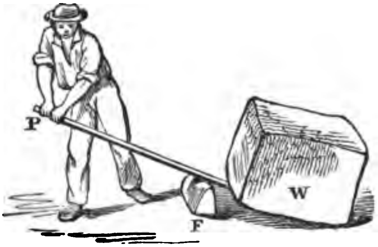

Fig. 14.

weight is between the fulcrum and the power, as

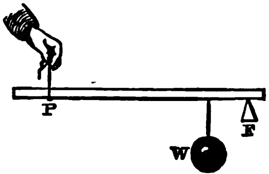

Fig. 15.

in Fig. 15, the lever is of the second kind. Fig. 16 is another example.

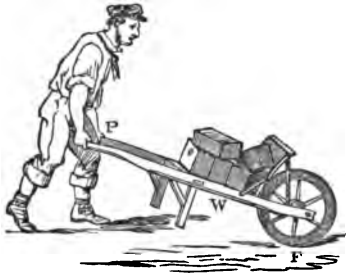

Fig. 16.

When the power is between the weight and the fulcrum, as in Fig. 17, the lever is of the third kind. Fig. 18 is another example.

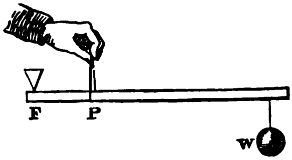

Fig. 17.

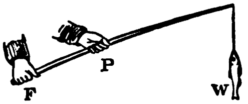

Fig. 18.

The object of using a lever of the first two kinds is to cause a small "power" to raise or move a great "weight." A boy with a long lever or crowbar will be able to move as large a block of stone as a man could move with a shorter one, if the fulcrum were placed the same distance from the block in each case. To calculate the power of any lever it is only necessary to remember that *the power multiplied by its distance from the fulcrum must be as much as the weight multiplied by its distance from the fulcrum,* in order to obtain equilibrium. If the power be just a little more than this, it will be sufficient to move the weight. Thus, if in Fig. 13 the power at P is 4 lbs., and the distance from P to F is 3 feet, and if the weight at W is 12 lbs. and its distance from F only 1 foot, the two will balance each other, or will be in "equilibrium," because $4 \times 3 = 12$ and $12 \times 1 = 12$. By moving the fulcrum, so that it should be just 8 inches from W and 40 inches from P, a weight of 20 lbs. would be sustained by a power of 4 lbs. ($4 \times 40 = 160$ and $20 \times 8 = 160$). In every case there will be equilibrium if these two products are equal.

A little more power than that required to balance the weight will raise it; but it is evident that P will have to descend through more space than w will be raised. The spaces moved through will be in proportion to the distances from the fulcrum, so that with the lever what is gained in power is lost in speed.

In the third kind of lever it is speed which is required, and consequently a large amount of power is used to raise a small weight. The power of the third kind of lever may be calculated in exactly the same way as that of the other kinds.

The different kinds of levers are only adapted for raising weights through short spaces. When the weight has to be raised through a long distance, some form of wheel and axle is often used. This is nothing more than a method of giving a

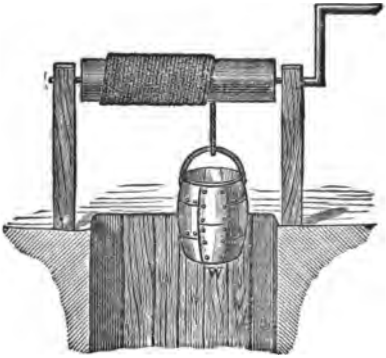

Fig. 19.

continuous motion to the lever, as in the windlass, Fig. 19. The capstan, Fig. 20, is another

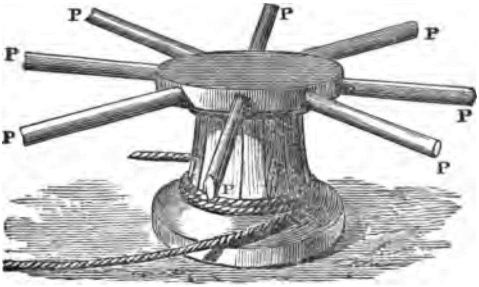

Fig. 20.

common form, in which the axle is placed upright. In the capstan the levers P P are generally movable.

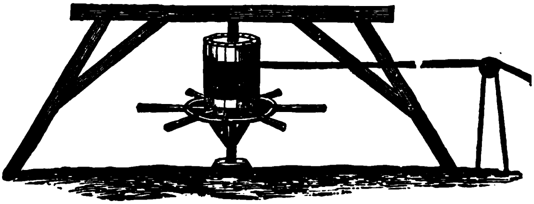

Fig. 21.

In Fig. 21 we have a combination of the capstan and pulley (see next page). In quarries—as we have already mentioned in Chapter VIII.—the crane (Fig. 12, p. 41) is a contrivance commonly used for raising weights. The horse-whim, Fig. 22, is another method of using the wheel and axle much used in mines.

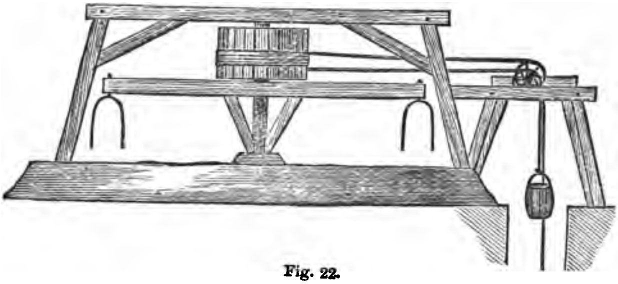

Fig. 22.

Sometimes the wheel is made to revolve by a stream of water, and very often by a steam-engine.

The pulley is a circular wheel of wood or metal, which is able to move freely on its axis. Generally it has a groove cut around the edge to keep the cord which works in it from slipping off. The cord of the pulley may be regarded as a perfectly flexible lever with equal arms.

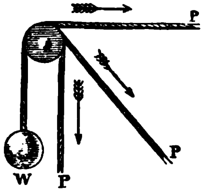

Fig. 23.

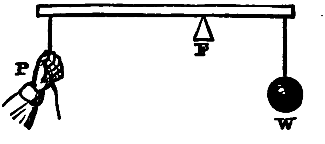

Fig. 24.

Pulleys are of several kinds, either "fixed" or "movable," "simple" or "compound." The single pulley only serves to change the direction of the power. Thus in Fig. 23 the weight will be equally sustained, whether the power be applied in the direction of the upper, middle, or lower arrow. This is not so with the lever, Fig. 24, for when the pull is straight downwards a smaller power will suffice than in other directions.

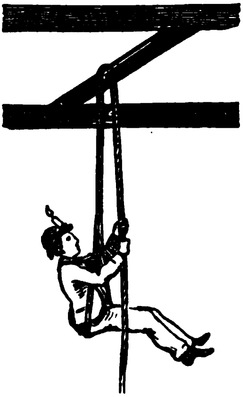

Fig. 25.

A modification of the pulley is seen in Fig. 25, a method often adopted by men who wish to raise or lower themselves from one level to another in a mine.

In Fig. 26 we have an example of a single movable pulley connected with a single fixed pulley. Here, supposing the weight to be 90 lbs., the cord perfectly flexible, and every part equally stretched, a power of 45 lbs. will be sufficient to balance the weight of 90 lbs., each of the cords *a* and *b* bearing half the weight. In this pulley it is evident that to raise the weight one foot each part of the cord *a b* must be shortened one

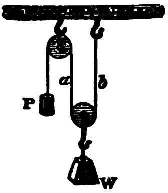

Fig. 26.

foot, and the power will therefore *descend* two feet; now 2 ft. × 45 = 90 and 1 ft. × 90 = 90, so that here, too, "what is gained in power is lost in speed." The same rule holds good with the pulley, Fig. 27, and, indeed, in all pulleys of one cord. In Fig. 27 the weight is supported by three movable pulleys, or six distinct portions of cord, so that 1 cwt. at P will balance 6 cwt. at W. In raising W, however, P must descend 6 feet for every foot the weight is raised.

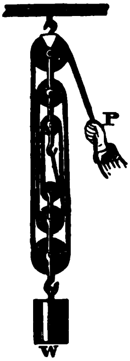

Fig. 27.

In some forms of pulley several distinct cords are employed, as in Figs. 28 and 29. In Fig. 28 a power of 1 cwt. will sustain a weight of 8 cwt., and in Fig. 29 the same power will support 27 cwt.

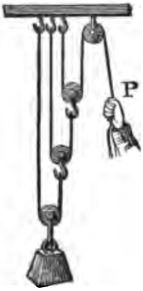

Fig. 28.

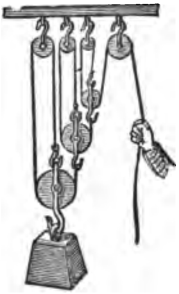

Fig. 29.

CHAPTER XI.

OF THE MECHANICAL POWERS (*continued*).

The inclined plane is the most simple of all the mechanical powers. When a quarry-man wishes to get a heavy block of stone into a cart he often places a short plank, as in Fig. 30, resting on the ground at one end and sloping upwards to the hinder part of the cart. To reduce the amount of rubbing or "friction" against the plank he often puts several rollers of wood or iron under the block. It is evident that with a long plank the slope will be less than with a short one, and the longer the plank the easier it will be to push or pull the weight into the cart. The mechanical advantage is in all cases just as much as the length of the plane exceeds the height of its upper end. If the plane be four times as long as

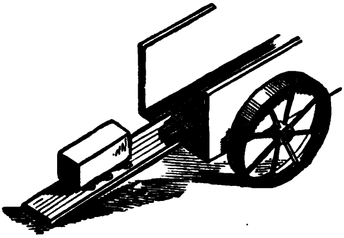

Fig. 30.

it is high a force of 1 cwt. will keep a weight of 4 cwt. from moving down, and a little more will push it up. It is evident, however, that to raise the weight 1 foot it will have to be moved 4 feet.

Inclined planes are of continual use in mining and quarrying. In coal mines the loaded trucks often descend by their own weight from the place of work to the bottom of the shaft, and in some few metal mines an inclined shaft has been dug from the surface to the bottom of the mine. Fig. 31 shows the inclined shaft at the "Crowns" mine, St. Just, Cornwall, which is driven out far under the sea.

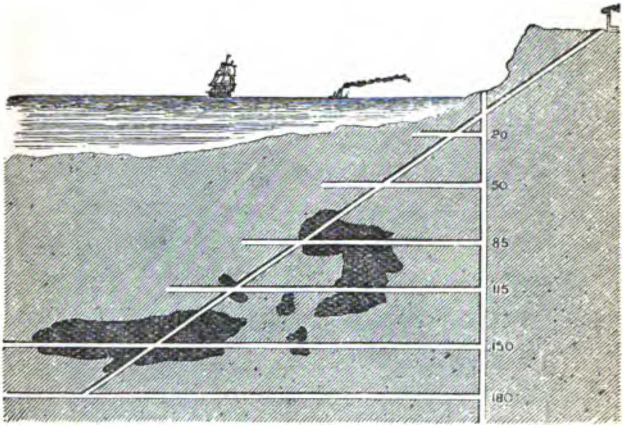

Fig. 31.—Inclined shaft at the Crowns Mine, St. Just, showing workings under the sea.

The wedge is an inclined plane in which the plane itself is made to move. It is much used in splitting rocks in mines and quarries, or for splitting timber: in these cases the inclined plane is usually double. The wedge is often used for raising weights through short distances, as in Fig. 32. The picks used in mining are only modifications of the wedge and lever combined.

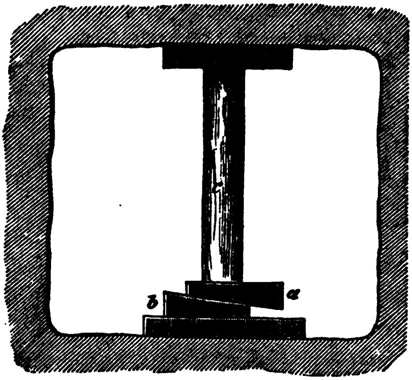

Fig. 32.
a b, wedges used for tightening the pillar, *c*, and sometimes for raising the roof, or sustaining its weight.

The screw is another contrivance for doing work by means of a movable inclined plane. This plane, which is called the "thread," is wound around an axis. It is very much used for tightening the different parts of machines, when it is worked by means of levers called "spanners."

Sometimes the screw is combined with a lever, as in the screw-press. With such a screw and lever the power accumulated is very great; but the motion is proportionately slow. Supposing the lever to be 2 feet long from the centre of the screw to the end, and the distance between the "threads" of the screw to be 1 inch, the outer end of the lever will move around a circle of 4 feet diameter, so that to reduce the distance between the cheeks of the press 1 inch, the outer end of the lever will travel more than 150 inches. Not reckoning friction, 1 lb. at the outer end of the lever will overcome a resistance of 150 lbs. between the cheeks of the press; but the friction in the use of the screw is usually very great.

These are the simple principles made use of in all kinds of machinery, however complicated. In all of them the *source* of the power is immaterial; it may be "man-power," as when a windlass is used to raise ore from a shallow mine; "horse-power," as in the horse-whim; "water-power," when a stream of water is made to move a water-wheel; "wind-power," as in the windmill; or "steam-power," used by means of a steam-engine.

In the steam-engine the power is obtained first of all by heating water in a "boiler" until it is changed into steam. The steam is then used to cause a "piston" to move up and down, or backwards and forwards, in a cylinder, and this in its turn to work pumps or turn wheels, as may be required.

The cylinder is a sort of pipe, made very wide in proportion to its length. The piston is a plug which fits tightly inside the cylinder. The piston-rod is attached to this, and serves to convey the motion of the piston to the point required. The two ends of the cylinder are closed, and the piston-rod passes through a "stuffing-box" in the upper end or "cover." Fig. 33 shows cylinder, piston,

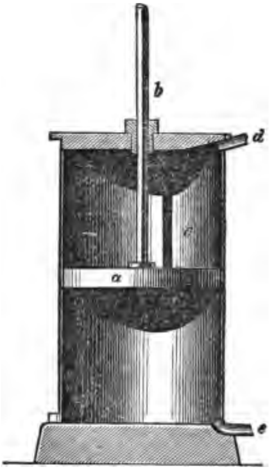

Fig. 33.
a, piston; *b*, piston-rod; *c*, cylinder; *d*, *e*, steam-passages.

and piston-rod. In such a cylinder the steam is first allowed to pass from the boiler along a steam-pipe into the cylinder, through *d* or *e*. Supposing the steam to pass into the cylinder at *d*, it will press the piston down to the bottom of the cylinder. It is then withdrawn by the opening of a valve into a condenser, or allowed to escape into the air, and at the same time a fresh quantity of steam is allowed to pass under the piston at *e*, so as to raise it to the top of the cylinder. In this way the piston continues to move up and down, and by means of the piston-rod to work the other parts of the engine. In the earlier steam-engines the different valves had to be moved at the proper time by an attendant; but all engines now made are self-acting—that is, some moving part of the engine is made to keep them moving after the first start.

All engines in which the steam acts alternately on each side of the piston are called "double-acting." In many pumping-engines the steam only pushes down the piston, so as to raise the heavy pump-rods, and then, the steam being withdrawn, the weight of the pump-rods raises the piston. These engines are said to be single-acting.

In pumping-engines the pump-rods are attached to one end of a great beam, which is seen projecting from the engine-house, the piston-rod being fastened to the other end. In winding and stamping-engines the outer end of the beam is made to turn a great wheel. There are many contrivances in pumping and winding engines for securing smooth and continuous motion with the smallest amount of variation; but the source of the power will be understood by these few remarks.

CHAPTER XII.

OF THE CHEMICAL ELEMENTS.

THE earth and all it contains is made up of about seventy perfectly distinct substances called *elements*. These elements are so called because chemists have not been able to "decompose" them, that is, to get from them two different sorts of matter.

When two or more elements are combined together a *compound* is formed. Very many natural substances, such as *water* and *iron-rust*, are compounds of *two* elements; others, such as *limestone*, contain *three;* while very few natural compounds contain more than *four* or *five* elements. A few of the elements—such as gold, silver, copper, carbon, and sulphur—occur sometimes uncombined with any others, when they are said to be "native."

Compounds are very different from *mixtures*. A mixture is partly like each of the substances of which it is made up; but a compound is often quite different from either. Thus, a mixture of "Oxygen"—a gas which causes any burning body placed in it to burn very rapidly, and "Hydrogen"—a very combustible gas—forms a kind of air which explodes violently when a light is applied. The explosion is simply the result of the very rapid change of the *mixture* into a compound. The compound of Oxygen and Hydrogen so formed is *steam*, which is neither combustible nor able to support the combustion of other substances, but which is often used to *put out* fire.

Again, the air we breathe is a *mixture* of Oxygen with another gas called "Nitrogen;" but when these gases unite to form compounds, one is a gas which produces a kind of intoxication (laughing gas), while some others are deadly poisons.

A very large number of natural compounds are found in mines or quarries. In these some of the elements occur very rarely (just as the letters x and z are rare in English words); others are found in small quantities in all parts of the world, but are never common; while others, again, are both common and abundant. We shall now proceed briefly to describe the peculiarities of the chief elements.

Aluminium is a malleable white metal which has been obtained from clay within the last half-century. It was discovered in the year 1828 by a German chemist called Wohler. It is about as hard as zinc, very light, and does not readily tarnish. It is used for making jewellery, &c.

Antimony is a brittle metal of bluish-white colour, which melts very readily and passes away as a white vapour. It is not much used, except to mix with other metals to form alloys, for printers' type and other purposes.

Arsenic is a brittle metal of a greyish colour, very fusible and volatile. It is not used in the metallic state, but several of its compounds are used for preserving skins and making paints. They are deadly poisons.

Barium is a metal which has been obtained in small quantities, and by a difficult process, from a mineral called Heavy Spar.

Bismuth is a reddish-white metal which is used for nearly the same purposes as Antimony.

Calcium is a white metal which has been obtained in small quantities, and with difficulty, from limestone.

Chromium is a hard metal of grey colour, which has been prepared from a mineral called Chrome Iron Ore. Many beautiful colours used by artists contain a small proportion of Chromium.

Cobalt is a metal which occurs in several colours used by artists.

Copper is a well-known red metal, very malleable, and capable of being rolled into thin plates or drawn out into thin wire. It is much used for making brass.

Gold is a well-known yellow metal which occurs in small quantities in many parts of the world. It is much valued on account of its beauty, and also because it does not tarnish. Much used for jewellery, coinage, and as gold leaf for ornamental purposes.

Iron.—The most important and abundant of all metals.

Lead.—A useful soft metal, of bluish-white colour; much used for making the roofs of buildings, and for many other purposes.

Magnesium.—A white metal which burns with a very brilliant white light. It is much used for this reason by photographers and fire-work makers. It is contained in Epsom Salts and many limestones.

Manganese.—A hard grey metal, much like iron, which is occasionally prepared from a common mineral called "Black Oxide of Manganese." This substance is sometimes mixed with iron ores before smelting, being thought to improve the character of the iron.

Mercury.—A well-known fluid metal, commonly called "Quicksilver," of great value for use in barometers and other philosophical instruments; and also in the separation of gold and silver from their ores.

Nickel.—A hard white metal much used in making German silver.

Platinum.—A greyish-white metal, very heavy and very infusible, which is not acted upon by any ordinary acid. It is much used by chemists in their experiments because of these properties.

Potassium.—A soft reddish-white metal, which is so light as to float upon water. It takes fire when thrown upon water. It is contained in and extracted from Potash.

Silver.—An important white metal much used for coinage and for ornamental purposes, as well as in the art of photography.

Sodium.—A bluish-white metal, so soft as to be readily cut with a knife, and so light as to float upon water. It is obtained from Soda.

TIN.—A beautiful white metal very much used for coating thin iron plates to preserve them from rusting. It is also melted with copper to form the valuable alloy known as bronze.

ZINC.—A well-known metal of greyish colour, much used for the roofs of houses, and for making brass, which is an alloy composed of copper and zinc in variable proportions.

All the above are *metals*, and there are many others which are so rare, or so little used, that we do not here refer to them. Of elements which are not metals (metalloids), we may briefly mention:—

BORON.—A very hard solid contained in borax, a substance much used in the arts.

BROMINE.—A heavy dark-brown liquid, having a very powerful odour, which is obtained from sea-water.

CARBON.—A solid, well known as Black Lead and Charcoal. The diamond is the purest carbon known, and it is also the hardest substance known.

CHLORINE.—A greenish-yellow gas, obtained from common salt, which is much used for bleaching purposes. It has a very powerful suffocating odour, and is extremely poisonous if taken into the lungs.

FLUORINE.—A substance contained in the common mineral called Fluor Spar.

HYDROGEN.—A colourless gas, highly combustible, which forms one-ninth part by weight of pure water.

IODINE.—A bluish-black solid, obtained from sea-weed.

NITROGEN.—A colourless gas which forms four-fifths of the atmosphere.

OXYGEN.—A colourless gas which very strongly supports combustion. It forms eight-ninths of all water, and one-fifth of the atmosphere.

PHOSPHORUS.—A very combustible solid substance obtained from bones. It is also contained in the curious stones called Coprolites, which are so largely used for manure.

SILICON.—A very hard solid which enters largely into the composition of very many rocks.

SULPHUR.—A yellow solid which is found in the neighbourhood of many volcanoes. It is also a constituent of very many metallic ores, and of some rocks.

CHAPTER XIII.

OF CHEMICAL COMPOUNDS.

WE have said that the elements unite together to form compounds. It is found that they always do so in certain definite proportions. Thus—12 parts by weight of *carbon* will combine with 16 parts of *oxygen* to form *carbonic oxide*, or with 32 parts of oxygen to form *carbonic acid* (often called carbonic anhydride); but not in other proportions.

Again, 35·5 parts of chlorine combine with 1 part of hydrogen to form hydrochloric acid; but no compound in other proportions can be formed.

Sometimes iron is used to displace copper in a compound, when it is found that 56 parts of iron will take the place of 63·5 parts of copper, hence 56 parts of iron are said to be *equivalent* to 63·5 of copper. These weights therefore—16 for oxygen, 12 for carbon, 35·5 for chlorine, 1 for hydrogen, 56 for iron, and 63·5 for copper, are called *atomic weights*, *unit weights*, or sometimes *equivalents*.

Some elements are *heavy*, others are *light*. This difference is conveniently expressed by comparing their weight with that of water. This is called the *specific gravity* of the substance. The weights of solids and liquids are referred to water; those of gases are now usually referred to hydrogen. In books on chemistry the elements are usually indicated by letters, rather than by their full names. These *symbols*, as they are called, become a kind of shorthand to those who are familiar with them. In the table which appears at the end of this chapter we have brought together the names, symbols, atomic weights, and specific gravities of all the more important elements.

We have mentioned that gold, silver, and some few other substances occur uncombined with other substances. Gold is usually found in this form; the other metals occur mostly as "oxides," "sulphides," "chlorides," or "carbonates;" while the rocks in which they occur are mostly "carbonates" and "silicates." Oxides are compounds of oxygen, with other elements; carbonates and silicates contain, besides oxygen, *carbon* or *silicon*. Sulphides and chlorides contain no oxygen, but are compounds of *sulphur* or *chlorine* with the metals. These substances will be further referred to in future chapters.

In the accompanying table of the elements those which are printed in large capitals, like IRON and OXYGEN, are of very great importance, and very abundant; others, such as BISMUTH and PHOSPHORUS, are of less importance; while the rest are either very rare or very little used. The rarest of all are not mentioned.

A. Metals.

Name.	Symbol.	Atomic or Unit Weight.	Specific Gravity.
Aluminium	Al.	27·5	2·6
Antimony	Sb.	122·	6·7
Arsenic	As.	75·	5·8
Barium	Ba.	137·	4·5
Bismuth	Bi.	208·	9·8
Calcium	Ca.	40·	1·6
Chromium	Cr.	52·5	6 0
Cobalt	Co.	58·8	8·5
COPPER	Cu.	63·5	8·8
GOLD	Au.	197·	19·5
IRON	Fe.	56·	7·8
LEAD	Pb.	207·	11·4
Magnesium	Mg.	24·	1·7
Manganese	Mn.	55·	7·5
MERCURY	Hg.	200·	13·6
Nickel	Ni.	59·	8·8
PLATINUM	Pt.	197·	21·5
Potassium	K.	39·	0·86
SILVER	Ag.	108·	10·5
Sodium	Na.	23·	0·97
Tin	Sn.	118·	7·29
Zinc	Zn.	65·	7·0

B. Metalloids.

Name.	Symbol.	Atomic or Unit Weight.	Sp gr. as Gas.	Sp. gr. as Solid or Liquid.
Boron	B.	11·	—	2·6
Bromine	Br.	80·	80·	3·
CARBON	C.	12·	—	1·5-3·5
CHLORINE	Cl.	35·5	35·5	—
Fluorine	F.	19·	19·2	—
HYDROGEN	H.	1·	1·	—
Iodine	I.	127·	127·	4·9
NITROGEN	N.	14·	14·	—
OXYGEN	O.	16·	16·	—
Phosphorus	P.	31·	79·	4·3
SULPHUR	S.	32·	32·	2·0
Silicon	Si.	28·	—	2·5

CHAPTER XIV.

HOW METALS ARE EXTRACTED FROM THEIR ORES.

THE metals are extracted from their ores by different processes of *smelting*, and the branch of science which treats of such processes is called *Metallurgy*.

When *Oxides* are heated with *Carbon*, the oxygen they contain combines with the carbon to form carbonic oxide or carbonic anhydride, which passes away as gas, the ore being thus "reduced." The carbon used is either in the form of wood, charcoal, or coal.

When the oxides are mixed with veinstone, or other impurities, fluor spar, carbonate of lime, or other "fluxes," are added with the carbon. These fluxes combine with the impurities to form a "slag," which floats on the top of the melted and reduced metal, when it may be skimmed off, or run off by a hole in the side of the furnace.

If the ores to be smelted are carbonates, the same treatment is adopted, but they are first *roasted*, and this not only expels any moisture which may be present, but partly reduces them to oxides by driving off carbonic anhydride. Sulphides, and ores containing arsenic, are als roasted to convert them into oxides, and to expel the sulphur and arsenic as far as possible. These substances were formerly allowed to escape, but they are now collected in long passages, or "flues," and afterwards sold.

Lead ores generally contain enough silver to pay for extraction. Several methods of extracting the silver are in use, and in all of them the object is, first, to concentrate the silver from a large quantity of ore into a small quantity of lead, and afterwards to obtain the silver from the "rich lead."

Gold and silver are extracted from large quantities of waste matter by the aid of *mercury* or quicksilver. The mercury is well mixed with the finely powdered and properly prepared ore, when it dissolves out all the precious metal. By afterwards heating the "amalgam" of mercury and gold, or mercury and silver, the mercury is driven off as vapour, while the precious metals are left behind. This method is called "*amalgamation.*"

Mercury and zinc are metals which can be easily converted into vapours, and these are obtained from their ores by "*distillation.*" In this process the ore, &c., is first heated until the metal is converted into vapour, leaving all impurities behind; this vapour is then conducted by pipes into separate "*condensing chambers,*" where, as it cools, it settles down in the metallic state.

The smelting of ordinary yellow copper ore involves six distinct *roastings* and meltings. This ore contains besides copper, sulphur, iron and quartz, and generally more or less arsenic, with small quantities of several other metals. The proportion of copper is from about five to thirteen per cent. The processes are as follows:—

1st. Roasting to drive off the sulphur and arsenic.

2nd. Melting to get rid of part of the iron and the quartz, as a slag. The product is "coarse metal."

3rd. Roasting to convert the rest of the iron into oxide.

4th. Melting to get rid of the oxide of iron. The product is called "fine metal."

5th. Roasting to get rid of the remainder of the sulphur, forming "blistered copper."

6th. Refining to form "tough-cake."

Sometimes some of these processes need to be repeated, making as many as ten processes in all. Last of all the melted metal is covered with pieces of charcoal, or coal of a peculiar kind called anthracite, and stirred with a green pole of birch-wood. The wood gives off much steam, and this in bursting and bubbling through the melted metal carries up with it to the surface all the remaining impurities, leaving the metal soft, tough, and of a light red colour. This "poling" must not be too long continued or the copper will be brittle. At the proper moment the pole is taken out, and the copper dipped up in iron ladles lined with clay, and poured into moulds so as to form ingots of fine copper.*

One of the simplest of all smelting processes is that of tin ores. The ore is first of all purified as much as possible from the waste matters with which it is associated, by the various dressing processes in use at the different mines, so that it reaches the smelting-house in a much purer state than most other ores. It is indeed a tolerably pure oxide of tin, but it contains small quantities of iron, copper, arsenic, and several other metals, besides sulphur and silica. The "black tin," as it is called, is always in the state of a fine powder, and this is mixed with about one-sixth its weight of "culm," a hard and shining kind of coal, and heated strongly in a furnace of peculiar construction, called a reverberatory furnace. Sometimes a little fluor spar is added to assist in the formation of a "slag," a kind of glass which floats upon the surface of the melted metal, and which contains the greater part of the impurities of the ore. The fire is made to burn moderately at first, afterwards more intensely; the flames as they pass over the ore in their way to the chimney are reflected down upon it by the arched roof of the furnace, and the oxygen of the ore combines with the carbon of the culm to form carbonic oxide and carbonic acid, which escape up the chimney. The melted slag being then scraped off the surface, the metal is allowed to run into a large cast-iron pan, as "coarse metal," containing about ninety-five parts in the hundred of pure tin.

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* A great deal of copper is smelted in blast furnaces, especially in America and Germany.

The coarse metal is refined by two processes called *liquation* and *boiling*. The liquation is effected by piling up the blocks of coarse metal in a furnace and melting out the tin at as low a temperature as possible into a refining basin. As pure tin melts at a lower temperature than impure, that which runs into the basin is purer than the blocks which were placed in the furnace. This melted metal is now stirred up with a piece of "green" wood, or a log of wet wood is thrust under its surface, when the steam given off from the wood rising up through the molten metal, carries with it to the surface such impurities as may be still present. This process is called "boiling," on account of the violence with which the steam escapes. It will be at once seen that the "liquation" and "boiling" of tin much resembles the "poling" of copper. The richer slags and skimmings taken from the tin in its various stages are afterwards added to the mixed ore and flux of a succeeding "charge" of the furnace.

The smelting of iron is almost as simple as that of tin, but as the metal only melts at a very high temperature the fire has to be urged to great intensity by currents of air called blasts, hence the furnace used is called a blast-furnace. Sometimes the blast consists of ordinary cold air, when the iron obtained is called "cold-blast" iron; but frequently the air is much heated before being forced into the furnace, in which case the product is called "hot-blast" iron. The previous heating of the air leads to a great saving of fuel, so that hot-blast furnaces, which were somewhat rare only a few years ago, are now exceedingly common in iron-producing districts.

CHAPTER XV.

OF VENTILATION, ETC.

The importance of good ventilation cannot be too well learnt. The air we breathe consists mainly of two very different gases, *oxygen* and *nitrogen*, in the proportion of about one to four. Of these gases oxygen is necessary to support life, while the nitrogen serves to dilute it and to increase its volume. This oxygen of the air being taken into the lungs in breathing, combines with carbon from the blood, and is converted into carbonic anhydride. This carbonic anhydride is injurious even when mixed with a large proportion of pure air, and should be removed as fast as it is formed. The air of mines therefore soon becomes quite unfit for breathing unless constantly renewed; hence the necessity of ventilation.

The impurity of the air is much increased by the powder smoke where blasting goes on, so that a more frequent renewal is necessary. In coal mines an additional impurity occurs in the form of "fire-damp," a gas which often issues in large quantities from the coals. This gas is not only injurious to breathe, but it forms, when mixed with air in certain proportions, a very dangerous mixture, which explodes when it comes in contact with the flame of a candle or lamp. The explosion itself is often terrible in its effects, but its immediate result is the production of an immense volume of steam and carbonic anhydride—called "choke-damp" by the miners. This choke-damp, after an explosion, spreads through all the workings of the mine and suffocates those men who were uninjured by the explosion. A perfect and thorough system of ventilation is the best safeguard against such disasters, since if a rapid current of air is constantly passing through the mine, no accumulation of fire-damp can take place. In coal mines this current of air is produced very frequently by means of a large fire at the bottom of the shaft. The heated air from the fire rises rapidly upwards through one division of the shaft, which is large, and divided into two or three parts by a brattice, as already described. Cold and fresh air passes at the same time downwards, and is guided by brattices into the parts of the mine from which the foul air is being withdrawn by means of the fire. To further guard against explosions different kinds of *safety-lamps* are now provided in all "fiery" mines.

In these safety-lamps the flame is surrounded by wire gauze, which is found to be a sufficient protection in ordinary cases. The explosive vapour is able to pass inwards so as to be slowly burnt, but the flame is unable to pass outwards to fire the dangerous air of the mine. Sometimes, however, the miner meets with a "blower" of gas, that is, a stream of gas issuing from the coal in a powerful jet. Against such a stream the wire gauze is not a sufficient protection, nor yet against a very powerful current of air, which sometimes forces the flame outwards through the gauze. Accidents are, however, far more frequent from the occurrence of imperfections in the gauze or from the recklessness of the men in working with naked lights, or tampering with their lamps. The experiments which led to the invention of the safety-lamp were made by Sir Humphry Davy many years since, and a somewhat similar safety-lamp was constructed by the celebrated George Stephenson about the same time.

An improved form of lamp has been introduced into some of the Welsh coal mines within the last few years, in which the surface of wire gauze is much reduced and thoroughly protected from damage and also from currents of air and blowers, by a casing of glass. This seems to be really a safety-lamp, no explosion having occurred in any mine where it is used.

In metal mines the impure air to be removed is that resulting from the breathing of the men, the burning of the candles, and the powder-smoke from blasting. Sometimes machines are used in such mines to force pure air in or to withdraw the foul spent air, but usually the natural ventilation due to the numerous shafts is considered sufficient. The bottoms of such mines are, however, often very unwholesome from imperfect ventilation, and the men suffer much from this cause.

CHAPTER XVI.

OF GEOLOGY.

THE ground upon which we tread, as deep down as we know anything about it, is often called the "crust of the earth." The science of Geology teaches us that this "crust" was not always in the same state as it is at present. What is now sea was once land, and all the present land was formerly covered by water; and we know that such changes are even now going on in many parts of the world.

Under the coating of "soil" everywhere, at a greater or less depth, the "rocks" are to be found. This term is applied by geologists to all the materials of which the crust of the earth is made up, except the surface covering or soil, whether hard or soft, so that granite, limestone, slate, sand, and clay, are all called rocks.

The study of the rocks soon shows that they are of many different kinds, and have been formed in different ways, but geologists often divide them into two distinct groups, called "stratified" or "aqueous," and "unstratified" or "igneous."

The stratified rocks, such as limestone, sandstone, and clay, were at first formed mostly at the bottom of the sea or of great inland lakes, having settled down as a sediment in horizontal beds; hence they are called "sedimentary" rocks. These stratified rocks are sometimes found to be very much disturbed from their original position, and very much altered in their appearance where they come in contact with igneous or unstratified rocks, being so much twisted and hardened as to be quite unlike ordinary aqueous rocks. Such altered stratified rocks are called "metamorphic." Roofing slate is such a metamorphic rock.

The unstratified or igneous rocks are found sometimes under the stratified, sometimes spread out over them, and very often as if forced up through them from below in a melted state, altering them greatly by heat and pressure. These igneous rocks are of two kinds, called "volcanic" and "plutonic." Volcanic rocks, such as "lava," "pumice," &c., have been thrown out from volcanoes or burning mountains in a melted state, and have afterwards cooled down into solid masses. Plutonic rocks, such as granite and porphyry, have been formed at great depths in the earth's crust, and afterwards pushed up through the stratified rocks.

Coal is nothing more than the woody matter of ancient forests, which has been much altered by the lapse of time, heat, and pressure. It often contains portions of the plants in which the woody structure is still quite distinct, and the bed of hardened clay which is always found beneath each bed of coal is often quite filled with the roots of the plants, together with impressions of their leaves upon its upper surface. Some of these impressions are very beautiful indeed, and they are generally quite common in the rubbish-heaps of coal mines.

The study of geology teaches us that rocks of different kinds have been formed at different times. That particular set of rocks which holds all the good coal of Great Britain and most of that of North America, is called the Carboniferous system. The rocks of this and other systems are known by those who study them partly by their position and partly by the peculiar kinds of animal and vegetable remains, called "fossils," which are imbedded in them. It is therefore important, before commencing to search for coal in a new district, to obtain the advice and assistance of the geologist, as without such advice large sums of money may be wasted in working in neighbourhoods where there are either no carboniferous rocks, or where they are at too great a depth to be profitably worked. Such costly mistakes have been frequently made in past times, and all who seek for coal without having studied the science of geology are liable to make them in the future.

Although most of the good coal of Great Britain and North America is found in Carboniferous rocks, yet small deposits of a very inferior kind occur in other much newer rocks, called Oolitic and Miocene. On the continent of Europe the Miocene coals are of considerable importance, as are also the Oolitic coals of India.

We have said that limestone has been usually formed at the bottom of the sea. It is sometimes quite full of the shells and hard parts of marine animals which were once alive, especially of great quantities of sponges and corals. Chalk is also hardened mud which once formed a sea-bottom, but the microscope shows that it is almost entirely made up of the hard outer coverings of minute animals—so small, indeed, as to be quite invisible to the unaided eye. In this fine mud the remains of larger animals are often quite common, and altogether it is much like the mud of many parts of the Atlantic Ocean at the present time would be if hardened by pressure and drying.

Sandstone is simply the consolidated sand of the sea-shore and of the bottom of shallow seas. Under the microscope it is seen to be made up of rounded particles of rock fastened together, sometimes with lime, sometimes with a kind of flinty matter called silex. On the north coast of Cornwall, the north-west of France, and in many other places, a kind of sandstone is formed from sand blown inward on the land from the sea-shore. This sand contains a great deal of lime in the form of small particles of shelly matter, and the rain falling upon the upper layers of sand dissolves out the lime and carries it downwards through the mass of sand. The lime is stopped by the lower layers of sand, and serves as a cement to bind the sandy grains firmly together, and in this way much building stone of fair quality is constantly being formed by natural causes out of the sand of the sea-shore. A similar process at the bottom of a wide sea would form beds of sandstone such as are dug out of very many quarries in our country. The best kinds of sandstone, however, are held together not by lime but by silex, as we have already mentioned.

The whole series of stratified rocks of Great Britain are shown in their relative positions in Fig. 34, nearly as they would be crossed in proceeding from the west to the east of England. Those on the left hand are the oldest, or "lowest" in geological language, because the other rocks rest upon them, having been formed since. In some instances the lower or older rocks really form higher land than newer rocks, as shown in the figure, having been forced up from below by the same force which produces earthquakes and volcanoes.

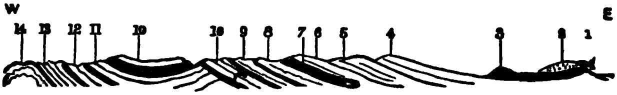

Fig. 34.

CHAPTER XVII.

OF THE STRATIFIED ROCKS.

THE different stratified rocks shown in Fig. 34 are numbered from east to west. We now proceed to describe the chief peculiarities of each system or formation, beginning with those which have been formed most recently.

1. POST TERTIARY.—All deposits of mud and sand formed near the mouths of rivers, in harbours, or on low lands which are occasionally flooded, deposits of peat in moist places, &c., are known as Post Tertiary.

2. PLIOCENE.—Certain rocks found in Suffolk and Essex which yield large quantities of the bones, teeth, and excrement of fishes and other animals called *coprolites*, which are used for making artificial manures. These rocks are usually known as the *coralline crag* and the *red crag*.

3. MIOCENE.—A few small patches of limestone in the Isle of Wight, and some beds of lignite—an impure kind of coal which occurs at Bovey Tracy in Devonshire, in the north of Ireland, and in Scotland—are believed to be of this age.

4. EOCENE.—The large deposits of stiff clay which are found under and around London, the

greater part of Essex, the south of Hampshire, and the north of the Isle of Wight, as well as in other places, belong to the Lower Eocene, together with many beds of sand and gravel, and a few beds of limestone. The clay is used largely for brick-making, and certain hard lumps which occur in it, called *Septaria*, are used for making cement; while other lumps of sulphide of iron (*Pyrites*) are used for making sulphuric acid. Many of the sands are much used by glass-makers and iron-founders, the limestone is used for building, and the flint and gravel for road-making.

The Pliocene, Miocene, and Eocene together, are often called *Tertiary* or *Cainozoic*.

5. CRETACEOUS.—Very thick beds of chalk, with layers of black flints in the upper parts, together with masses of clay, sand, and sandstone, which occur very largely in the east and south of England under the Tertiary rocks, are called Cretaceous. The chalk is much used for burning into lime, and occasionally for building, the flints for road-making, building, and pottery, and the sand and clay for brick-making. The sandstone, under the name of fire-stone, is valuable as a lining for furnaces. Below the chalk and sand fine beds of shelly marble are found in Sussex

and other places, which were formerly much used for ornamental purposes in the interior of buildings.

6. OOLITIC.—A large series of limestones, clays, and sandstones, with a few thin layers of lignite, which occur in the south of England, and in a broad band which crosses it in a curved line from Whitby in Yorkshire to Weymouth and Portland in Dorsetshire. Many of the limestones are of the kind called Oolitic, which seems to be made up of an immense number of little round grains something like the hard roe of a fish. The clays are of much value for brick-making, and the sands and sandstones are used for building purposes. The most important of the limestones are known as Portland stone, chiefly obtained from the immense quarries of the Isle of Portland, and used for building St. Paul's Cathedral and many other buildings in London; Bath stone, obtained from the quarries near Bath, and used in building Bath Abbey and other important buildings; Ketton stone, from Rutlandshire, used for Ely and Peterborough Cathedrals; Barnack or Casterton stone, much used in Cambridgeshire and Lincolnshire; Ancaster stone, from Lincolnshire; Painswick stone, and some others. The most important beds of clay are known as Kimmeridge

clay and Oxford clay, and are much worked at Kimmeridge and near Aylesbury.

7. Lias.—This system consists of many rather thin layers of limestone, used for lime-burning, together with many beds of clay more or less hardened, and very full of remains of shell-fish and other animals. It occurs under the Oolitic series, and is often reckoned as the lower part of it. Many valuable beds of ironstone occur in the Lias and Oolite of Cleveland, in Yorkshire,

8. Trias.—This consists of a thick series of red or brown sandstones and marls, with beds of rock-salt, and alabaster or gypsum. The sandstones are much used for building. The rock-salt is quarried for agricultural purposes, besides which it furnishes the salt of the *brine springs* of Cheshire and Worcestershire, from which the best table-salt is prepared. The beds of alabaster are used for ornamental purposes, and also for the manufacture of plaster of Paris.

These rocks, from the Trias upwards to the Cretaceous, are often called *Secondary* or *Mesozoic*.

9. Permian.—These rocks consist of thick beds of magnesian limestone, or dolomite, known as Bolsover stone, Roche Abbey, &c. Many of the beds are very valuable and durable building stones, others are somewhat prone to decay.

10. CARBONIFEROUS.—These rocks consist of many beds of coal, ironstone, sandstone, and hard clay, called the *Coal Measures*, thick masses of a hard and durable sandstone, called *Millstone grit*, because much used for millstones, and very thick beds of hard crystalline limestone or marble. Of these varied materials the coal fields, which occupy an area of about 1,000 square miles in Wales, and near 1,500 square miles in the north of England, as well as many large tracts of country in Scotland, Ireland, and other parts of the United Kingdom, are of the greatest importance. The coal is composed of altered vegetable matter, and it is usually associated with valuable beds of ironstone, from which a very large portion of the English iron is produced. The mountain limestone is valuable as a building stone, being much used for bridges, docks, &c., where great durability and strength are required. Much of it, too, is burnt into lime of excellent quality, and some of the beds which are full of the *petrified* remains of shells and corals form beautiful marbles.

11. DEVONIAN.—This system consists in some places, as in Scotland and Shropshire, of very thick beds of sandstones and *conglomerates* or *pudding-stones*, mostly of a red or brown colour,

and often very valuable as paving stones. In the north of Devonshire, and in Cornwall, they consist of slates and shales of various kinds, with beautiful compact limestones in some places. Most of the tin and copper lodes of Cornwall and Devonshire occur in these rocks, or in the granite against and upon which they rest. Very few good lodes of either have been found, however, more than a few miles from the junction. Some of the best roofing slates in the world come from quarries of Devonian rocks at Delabole, in the north of Cornwall.

12. SILURIAN.—A great thickness of slates, shales, limestones, and sandstones, which occurs chiefly on the borders of Wales. Many of the limestones are quite full of animal remains, often much altered.

13. CAMBRIAN.—An immense series of slates, sandstones, and mudstones, often very highly altered into roofing slate, or other highly crystalline rocks. They occur chiefly in Wales and Cumberland. These rocks upwards to the Permian are called Primary or Palæozoic.

14. HURONIAN.—A great series of rocks, some very highly altered, others much less so, occurring on the shores of Lake Huron.

15. LAURENTIAN.—These are highly altered crystalline rocks, occurring in the Hebrides and

perhaps the north-west of Scotland, under the Cambrian, Silurian, and Devonian rocks. They are named from their great development about the river St. Lawrence in North America.

The Huronian and Laurentian rocks, together with certain subdivisions which are even now being worked out, are often called *Azoic*.

Each of the systems of rocks which have been mentioned above, from No. 1 to No. 13 at any rate, has its own peculiar *fossils*, as the imbedded remains of animals and plants, which, in some instances, seem to form the greater part of the mass, are called; and by the study of these fossils geologists are often able at once to determine the series to which a rock belongs. In this manner the judgment of the geologist becomes most valuable to the miner, both in pointing out likely localities for finding given minerals, and in guarding against unprofitable and expensive searches in unlikely districts.

Most of the older rocks are found disturbed, upheaved, and much altered, in some parts, by rocks of the kind called igneous, which seem to have been forced up through them from below, or poured out over them in a melted state. As these rocks are best recognised by beginners by their mineral characters, we shall refer to them after describing the more important minerals.

CHAPTER XVIII.

OF MINERALS.

ANY natural substance, which has never formed part of a plant or animal, and which is in all parts of the same composition, is called a *Mineral.* In a wider sense, any substance which is dug up out of the earth for use is called a *mineral substance.*

Many rocks are made up of two, three, or more distinct minerals, or they consist of masses of impure minerals. Thus ordinary granite is a mixture of three distinct minerals, called *Quartz, Felspar,* and *Mica,* while ordinary limestone is a mass of more or less impure carbonate of lime or *Calcite.*

The science of Mineralogy teaches us how we may know one mineral from another; a matter of the greatest importance to all miners, especially as many minerals, which are much alike in appearance, are quite different in composition as well as in value. We shall in this and the following chapter briefly describe a few of the most important minerals, or those which are most commonly met with, under their common names. Those minerals which contain the common metals are usually called *ores*, the others are by miners often although somewhat erroneously called *spars*.

1. METALLIC MINERALS OR ORES.

COPPER.—The chief ores of copper, besides the metal itself, which often occurs in a pure state, when it is known as native copper, are the red, black, grey, purple, yellow, and green copper ores.

NATIVE COPPER may be easily known by its colour and extreme toughness. It is so malleable that it may be readily beaten out into thin plates by hammering.

RED COPPER Ore is an oxide of copper. It is quite brittle, and easily broken up into a red powder. When pure it contains nearly 89·0 per cent. of copper.

BLACK COPPER Ore is also an oxide. It is not so common as the red ore, nor so rich in copper. When pure it contains about 80·0 per cent. of metal.

GREY COPPER Ore is a sulphide, that is, copper combined with sulphur. It is grey in colour, and looks much like the metal lead; but, unlike lead, it may be broken up by the hammer. It contains 80 0 per cent. of metal. Another kind of grey copper ore is common in Germany, which often contains a little silver.

Purple Copper Ore, or *horseflesh ore*, is also a sulphide, but it is not so rich an ore as the grey, part of the copper being exchanged for iron. It is generally of a purplish-brown colour. Pure specimens contain nearly 70·0 per cent. of copper.

Yellow Copper Ore, or *Copper Pyrites ;* this is the most abundant ore of copper. It has a bright yellow colour, much like good brass. One kind often has a beautiful coloured tarnish, red, blue, green, and other tints mingled together; this is called *peacock ore.* Yellow ore is a sulphide of copper and iron, as the purple ore, but the purest specimens only contain 34·6 per cent. of copper.

Green Copper Ore, or *Malachite*, is much less common than either of the others; but it is a valuable ore when pure, as it contains 57·1 per cent. of copper. It is often mixed with a blue carbonate, which is of nearly the same value.

None of these ores of copper are very hard, all being readily scratched with a knife.

TIN.—Only one kind of tin ore is found in any considerable quantity; this is what is called *tin stone*, or Cassiterite. It is an oxide of tin, which when pure contains about 78·0 per cent. of metal. Its colour varies from light yellowish brown to quite black, but most varieties are of a dark brown colour. Sometimes it is found in valleys in the condition of dark-coloured pebbles. These are called *Stream tin.* All the varieties are very hard and very heavy. Black tin is the name given to all the kinds when prepared for sale, when they are usually in the condition of a dark-coloured powder.

LEAD.—The chief lead ores are two only, the *Sulphide* and the *Carbonate.*

GALENA is the sulphide of lead. It is of lead-grey colour, and usually of very bright metallic appearance. It is very easily broken, and usually breaks up into small square blocks. It is very heavy, soft, and easily melted. Pure specimens contain 86·6 per cent. of lead. This is the commonest of all the ores of lead.

CARBONATE OF LEAD is white or yellow, very heavy, and very soft. It is often dark brown on the surface. Pure specimens contain 77·0 per cent. of metal.

IRON.—The chief ores of iron are either oxides or carbonates; but a sulphide of iron, called pyrites, is often sought for on account of the sphur which it contains.

RED HEMATITE is an oxide of iron, of dark brown or black colour. It is called red hematite because its powder is red, and a heap of the ore always appears more or less red from the colour of the bruised portions. It contains 70 per cent of iron when purest.

Brown Hematite is also an oxide, but not so rich as the red hematite, as it contains a portion of water; its powder is brown, hence the name. Pure specimens contain about 59 per cent.

Magnetite is a magnetic oxide of iron, of a black colour; the powder also is black. It is the richest of all the ores of iron, containing 72·4 per cent. of metal when purest.

Carbonate of Iron is not so rich as either of the oxides. The kinds most commonly obtained are the clay carbonate, of a greyish-brown colour, containing a quantity of clay, and the black band, which contains a quantity of carbon or coaly matter. Pure carbonate of iron, often called Spathose Iron, contains 48·2 per cent. of iron.

Pyrites is a sulphide of iron of a yellow colour, sometimes much resembling yellow copper ore. It is always, however, easy to distinguish between them, as yellow copper ore is easily scratched with the point of a knife, while pyrites is too hard to be so scratched. It contains 53·3 per cent. of sulphur and 46·7 of iron when pure.

Mispickel, or White Mundic, although not worked as an ore of iron, contains both iron and arsenic, as well as sulphur. It is of bright greyish-white appearance, with a brilliant metallic surface. It contains 34·4 per cent. of iron, and 46·0 per cent. of arsenic. Most of these ores of iron are hard and heavy.

ZINC.—The usual ores of zinc are two only, called *Calamine* and *Blende.*

Calamine is a carbonate of zinc, usually of a white, grey, or brownish colour. It is neither very hard nor very heavy; pure specimens contain 59·3 per cent. of zinc.

Blende, or *Black Jack,* is a sulphide of zinc of a yellow, brown, or black colour; it is broken very easily, indeed, and the broken surfaces shine most brilliantly. The per centage of zinc is 67.

MANGANESE.—The chief ore of manganese is an oxide called **Pyrolusite**; it is quite black, and so soft as to soil the fingers. It contains 63·3 per cent. of the metal.

SILVER.—Besides the metal itself, which may be easily known by its colour and toughness, several ores of silver are known—such as the grey, black, light red, dark red, and horn silver. All of them are extremely rare in British mines; but a great deal of silver is got out of the lead ores of Cornwall and Devonshire.

GOLD is sometimes found in small metallic particles in the gravels and sands of some rivers in Scotland, Wales, and Cornwall; but it is always extremely rare. Sometimes particles of yellow copper ore, or of pyrites, are mistaken for gold; but it is very easy to distinguish them, as they break up into powder when struck with a hammer, while gold is only flattened out by such treatment. Hot nitric acid, too, will dissolve copper ore and pyrites; but it does not affect gold.

2. Non-Metallic Minerals, or Spars.

Quartz.—This is the most common of the spars in metal mines. It is very hard, and breaks into very sharp fragments, with bright curved surfaces. When pure it is quite colourless; but more often it is white, or tinged yellow, brown, or purple. Granite contains a large proportion of quartz. Flint and flint-gravel are composed of a peculiar variety of quartz called *Chalcedony.*

Sandstone is usually composed chiefly of grains of some form of quartz held together with some mineral cementing substance.

Fluor.—This is a common material in some mines. In Derbyshire it is often blue or purple, hence it is called Blue John. In Cornwall it is mostly green, and is called Cann. It is not so hard as quartz, and is much more easily broken; the fragments have *flat* shining surfaces.

Calc Spar, or Calcite, is common in some districts, it is usually white or yellowish. It breaks into fragments with flat surfaces like fluor, but is still less hard than it. It may be easily distinguished from fluor by means of vinegar or other acid; if placed in the acid it begins to dissolve immediately, giving off many bubbles of carbonic acid gas. *Limestone*, *Chalk*, and *Marble* are impure forms of calcite.

Felspar is harder than fluor, but not so hard as quartz. It is sometimes white, but more commonly yellow or pink. It may be known by its hardness and peculiar fracture. It is so hard that a good knife is required to scratch it; and it breaks into fragments, having two flat surfaces at right angles, or very nearly so, to each other. It occurs with quartz and mica in all granites.

Mica is a common mineral in some districts; sometimes white, but much more often of a brown colour. It may be easily known as it splits up readily into very thin plates, which may be bent backwards and forwards without breaking. It forms a considerable proportion of all kinds of *granite* and *gneiss* rocks, while the rock called *mica-schist* is almost entirely made up of mica and quartz. Scales of mica are often found in the joints and cleavage planes of *sandstones*, especially of those kinds which are called *flagstones.* When mica occurs in large sheets it is extremely valuable. Many important mines of mica are worked in Russia, Canada, and elsewhere.

HORNBLENDE is a dark-green mineral, with sometimes a brown, grey, or blue tint. It is rather heavy, and not too hard to be readily scratched with a knife. It is one of the toughest of all mineral substances, being very difficult to break. Very often it has a kind of fibrous structure; and sometimes these fibres are soft, and may be bent without breaking. One variety, called Asbestos, is so very fibrous, and the fibres are so flexible, that it has been made into a coarse kind of cloth, and also used for lamp-wicks. The rocks called Greenstone are largely composed of hornblende; and those called Basalt are mainly composed of a dark-coloured mineral, which much resembles Hornblende and is called *Augite.*

SERPENTINE is a green or red substance, often of curiously veined or mottled appearance, which feels smooth or greasy, is not very heavy, and is so soft as to be readily cut with a knife. It is occasionally fibrous, but generally quite compact. In some districts, as in the Lizard district of Cornwall, it forms great rock masses.

GYPSUM is a soft white, brown, or yellow mineral substance, which occurs as rock masses in Derbyshire, Cheshire, and other parts of England. It is so soft as to be readily scratched with the finger-nail. When burnt and ground it forms the valuable substance known as plaster of Paris. The fine-grained specimens, such as are used for ornamental purposes, are often called *Alabaster*, while a beautiful glassy variety, which splits up readily into thin slices, and which occurs in many beds of clay, is called *Selenite*.

Dolomite is much like calcite, but differs from it in containing much magnesia. It is a little harder, and often has a somewhat pearly appearance, when it is called Pearl Spar. Dolomite occurs in great rock-masses as well as a distinct mineral.

Chlorite is usually of a green colour, quite soft; sometimes in thin plates, like mica; but more often in earthy masses.

Schorl is dark brown or black, very hard and bright, and very easily broken; it often occurs in masses of long narrow crystals matted together

Barytes, or Heavy Spar, is not uncommon in some districts; it is mostly white, yellow, or brown; not very hard, but very heavy. It often breaks into fragments with smooth surfaces.

Rock Salt is an important mineral substance which occurs in immense beds in Cheshire, Germany, and many other regions. It is used in agriculture, in chemical manufactures, and in the preparation of table-salt, also in preserving food. It is readily recognised by its taste.

BORAX is a soft white substance obtained by evaporating the waters of certain lakes, or by washing the earth from the dried-up bottoms of such lakes. It is largely used in the arts, and is of great value as a preservative of food.

NITRATE OF SODA is obtained in a similar manner, very largely in Chili and Peru. It is used in making gunpowder, and still more largely in chemical manufactures.

SULPHUR is obtained partly by a kind of mining in volcanic regions, and partly from ores of copper during the roasting process. Its great use is in the manufacture of gunpowder, but it is also largely used in the manufacture of sulphuric acid.

MAGNESITE, or Carbonate of Magnesia, is a soft and white substance mined in the Balkan Peninsula. It is used in chemical manufactures.

APATITE, or Phosphorite, is a mineral which much resembles felspar, but is heavier and not so hard. It does not, however, break up into fragments, having smooth surfaces forming right angles. Some kinds are spongy in appearance and quite soft. Apatite is obtained in large quantities in the West Indies, Canada, Norway, and many other countries, and is used for making artificial fertilisers for use in farming.

3. COMBUSTIBLE MINERALS.

DIAMOND.—This well-known gem is the hardest of all substances. It consists of pure carbon, and does not differ chemically from black-lead or graphite, although its appearance is so different.

GRAPHITE, the well-known substance known as black-lead, is chemically nothing more than carbon. It is mined in Cumberland, Ceylon, and other countries, and is used for making pencils, crucibles, &c., &c.

COAL consists chiefly of carbon. Its mode of occurrence and the principal methods of mining have already been described.

OZOKERITE is a sort of natural wax occurring in beds in Galicia and elsewhere. It is obtained by a rude method of mining, and used in the manufacture of candles.

By a little practice in examining and handling specimens of these minerals, the young miner may soon learn to distinguish them from each other, and from others which are not so common, but which much resemble these. In this he will be much aided by comparing them as to hardness and weight, or specific gravity, while the colour of the metallic minerals will often be of much assistance. He may be aided still more if he will only learn the use of a little instrument known as the mouth blow-pipe, which can be purchased for a few pence. This little instrument is of use in testing the fusibility of the minerals—that is, their readiness or otherwise to melt—as well as in other simple ways; but to describe the mode of working would be foreign to the purpose of this little treatise, as several convenient books are written specially for that purpose.

CHAPTER XIX.

OF THE IGNEOUS AND METAMORPHIC ROCKS.

We have already observed that the unstratified or igneous rocks are divided by geologists into two groups, called *plutonic* and *volcanic*. Other rocks which were originally stratified are sometimes found, so much altered as to be much more like the unstratified than the stratified rocks. These are called *metamorphic*. In the present chapter we shall very briefly describe the more important of these igneous and metamorphic rocks.

GRANITE.—This is composed of the three minerals—quartz, felspar, and mica, in a crystalline condition, and all mingled indiscriminately together. Granite varies much in colour and in texture; but it always contains these three minerals. Some kinds of granite contain large crystals of felspar imbedded in the mass of smaller crystals, when they are said to be *porphyritic*. Granite is an undoubted plutonic rock.

GNEISS consists of the same minerals as granite, but they are differently arranged; they occur more or less regularly disposed in thin layers. Gneiss is often regarded as a metamorphic rock.

ELVAN, or elvan porphyry, often consists of the same ingredients as granite, but differently arranged. Much of the felspar is in an uncrystallized condition; while the other ingredients—crystals of felspar and quartz and scales of mica—are scattered irregularly throughout the mass. There is great variety in the appearance and composition of elvans.

SYENITE is a compound of quartz, felspar, and hornblende. It often much resembles granite, but may be distinguished from it by the presence of hornblende and the absence of mica.

SCHORL ROCK is a compound of quartz and schorl variously combined.

MICA SCHIST consists principally of quartz and mica; but the two minerals are arranged in layers, or foliated.

QUARTZ ROCK consists almost entirely of quartz, but contains occasional particles of other minerals.

SERPENTINE consists principally of the mineral serpentine in a more or less impure state. It is usually red or green, and not very hard.

GREENSTONE consists principally of some kind of felspar combined with hornblende. It is sometimes in large grains, but very frequently so fine-grained as to appear homogeneous. It is usually dark green, dark blue, or black, very tough, and capable of strongly affecting the magnetic needle, so that it is sometimes a source of inconvenience to the mine surveyor.

BASALT is often much like greenstone, but it is less tough and more fusible, and often of a grey or brown colour, not very hard, but very heavy.

TRACHYTE is a somewhat light-coloured rock, not so heavy nor so compact as basalt, but somewhat harder, and less easily melted. When very porous it forms *pumice*.

LAVA is the name given to the rocks which are poured out in a melted state from volcanoes. It is sometimes like basalt, and at other times like trachyte, both of these rocks being ancient lavas.

Clay Slate is a highly metamorphosed or changed clay. The kind called roofing-slate is hard and very strong, and splits readily into thin plates, which yield a ringing sound when struck. Killas is the Cornish name for the less perfectly cleavable kinds which occur in the mining districts.

Hornblende Rock consists of the mineral hornblende in a nearly pure state. It is the toughest of all rocks.

Many other rocks might be described, but these are sufficient for the elementary student. Metamorphic rocks, such as gneiss and mica schist, are found in large masses under the true stratified rocks in Wales, Cumberland, and Scotland. True plutonic rocks, such as granite, elvan, and the like, occur in the metal-producing districts of Cornwall and Devonshire, as well as in many parts of Scotland and Ireland, where metals are not found. Ancient volcanic rocks—greenstones and basalts—occur, the former among the slates or "killas" of Cornwall and Devonshire, the latter among the coal measures in the north and centre of England, and in other parts of the United Kingdom.

INDEX AND GLOSSARY.

A.

Account-house—the house in which the captains or agents of a mine keep the accounts and superintend the workings.

Acids—sour substances which turn vegetable blues red.

Adit—the water level of a mine. See p. 7.

Adlings—earnings.

Adventurers.—The owners of a mine, or the individuals who together form the mining company, are so called.

After-damp—the poisonous gas which results from an explosion of foul gas or fire-damp in a coal mine. It consists chiefly of the gas called carbonic acid, mingled with much steam. It is often called choke-damp, because it suffocates many of the men who may have been uninjured by the actual explosion.

Agents—the managers or overseers of a mine.

Air-pipes—pipes for conveying fresh air into the levels.

Alabaster, 104.

Alkalies—substances which have a caustic or burning taste, which restore the colours of vegetable blues, and which neutralise acids.

Alloys.—Combinations of two or more metals with each other are so called. Thus *brass* is an alloy of zinc and copper, and *bronze* of tin and copper.

Aluminium, 65.

Amalgam—an alloy of which mercury or quicksilver is one of the ingredients. See pp. 20, 74.

Amalgamation—the mode of separating gold or silver from their ores by means of mercury. See p. 74.

Analysis—the act of determining the composition of an unknown substance. *Qualitative* analysis determines the nature, and *quantitative* analysis the proportions, of the *various* substances.

Ancients—See *Old Men.*

Anhydrous.—Minerals and other substances which are free from or do not contain water are said to be anhydrous.

Antimony, 65.

Apatite, 105.

Aqueous, 83.

Arch—a piece of ground left unworked near a shaft.

Arenaceous—containing sand, or consisting principally of sand. Thus sandstones are said to be arenaceous rocks.

Argentiferous—containing silver. Thus, those kinds of galena which contain a considerable proportion of silver are said to be argentiferous.

Argillaceous—containing clay, or of a clayey nature. Thus, clays, shales, and clay-slates are said to be argillaceous rocks.

Arris—a sharp angle or corner, called also "arrage."

Arsenic, 21, 65.

Assaying—the art of determining the proportion of any given substance in an ore or mixture. It differs from an analysi only determining certain stated substances.

Atomic Weights, 70, 72.

Attle—waste or rubbish. The waste or rubbish of a mine is called "attle" or "deads."

Augite, 103.

Auriferous—containing gold. Pyrites, or sands containing gold, as is sometimes the case, are called auriferous pyrites, or auriferous sands.

Azoic rocks, 94.

B.

Back—a slippery or clayey joint or division in a bed of coal or hard rock. Sometimes called a "face."

Back of a lode—the upper part or outcrop of a lode at the surface of the ground; or that part which is "above" the men in any level.

Back-shift — the second set of miners working in any spot each day.

Bal—a common Cornish term for a mine. It applies rather to the surface than the underground workings.

Balk.—See *Nip.*

Balland—a Derbyshire term for lead ore in a finely divided state.

Bank or *Benk*—the surface of any mine—called "grass" by Cornish miners. Also the place from which the miners are turning out coal.

Banksman—the man who receives the coal at the top of the pit.

Bargain—an agreement between any party of miners and the managers of a mine to work at any stated point at a given rate.

Barium, 65

Bar Master—an officer who superintends the lead mines of Derbyshire.

Barrowmen.—See *Putter.*

Barytes, 104.

Basalt, 109.

Basaltic — consisting of or resembling basalt.

Bass or *Batt.*—See *Bind.*

Basset edge—that edge of a bed which appears at the surface. See *Cropping Out.*

Bast—a miner's supply of food for eating during work hours, called also "crib."

Beans—small coals.

Bearer or *Biard*—a large piece of timber used to support the engine and pumps in or over the engine shaft.

Beche or *Bitch*—a boring tool.

Bed, 4.

Bender—a piece of iron attached to barrels, &c., to which the pit-rope is affixed.

Bind—a quarryman's or collier's term for a dark slaty kind of hardened clay.

Binghole—a hole through which ore is thrown. A Derbyshire term.

Bismuth, 65

Bit—the working end or steel tip of a borer.

Black Copper Ore, 96.

Black Jack.—See *Blende.*

Black Tin — tin ore ready for smelting.

Blast—the air forced into a furnace. It is somethimes hot, sometimes cold. See p. 78.

Blasting—breaking away masses of rock by means of gunpowder or other explosives. See pp. 9, 39.

Blasting Cone—a comical plug of wood or metal, sometimes introduced into the upper part of a hole for blasting above the powder, to serve instead of tamping.

Blasting Needle—an instrument used in blasting.

Blende—an ore of zinc. See p. 100.

Blower—a violent discharge of gas from the coal in a coal mine.

Blow-pipe—an instrument for directing the flame of a candle or lamp upon any substance, for the purpose of testing its fusibility and other properties. It is of great value to the chemist and mineralogist. See p. 107.

Blue Elvan—a Cornish term for greenstone.

Blue John—the Derbyshire name for fluor spar.

Bob—the beam of the engine.

Bonnet—the covering to the safety cage, to prevent men from suffering from falling stones, &c.

Borax, 105.

Bord, *Board*, *Bord-gate*, or *Brow*—any gallery in a coal mine which is driven across the "face" of the coal.

Borer or *Borier*—the long tool or chisel used for boring holes for blasting in mines.

Boron, 68.

Bottoms—the lowest workings in a mine or in a level.

Boulders—large masses of rock of a somewhat rounded form.

Bowze—lead ore as cut from the lode.

Brakesman—the man in charge of a winding engine.

Brances—pyrites in coal.

Branches—small veins of ore in connection with a main or principal lode.

Brattice—in coal mining, a temporary partition made for the purpose of directing the current of air. See p. 31.

Breccia—a rock made up of *angular* fragments of other rocks. When made of *rounded* pebbles it is called a conglomerate.

Brittle—anything easily broken. In mineralogy the term is used in distinction to "tough." Thus schorl is brittle and hornblende is tough.

Brood — the heavier kinds of waste in tin and copper ores.

Brown Hematite, 99.

Bromine, 68.

Bryle—the traces of the presence of a lode at surface.

Bucking—a method of breaking the poorer sorts of copper and lead ores into small fragments by means of flat irons, called bucking irons. It is now nearly superseded by crushing machinery.

Bucking Iron—the iron with which bucking is done.

Bucking Plate—an iron plate on which the ore is bucked.

Bucklers.—See *Tacklers*.

Buddle—a contrivance for washing impurities from stamped tin ore. See p. 15.

Buddling — separating the ores from waste by means of the buddle.

Bunch—a rich deposit of ore of small extent.

Burden — the top or waste in stream-works, &c., which lies over the layer of stream-tin or other material sought for. The same word, or "over-burden," is used by quarrymen with reference to the waste which overlies the good stone in a quarry.

Burning—the operation of roasting an ore for the purpose of driving off sulphur, arsenic, moisture, &c. It is the same as calcining.

Burning-house—the place where the "burning" is conducted.

Burrow—a heap. The heaps of attle, deads, or waste thrown out from a mine are so called.

Butty—A person who contracts to raise coal from any given point in a mine at a certain fixed rate per ton, making his own arrangements with the miners.

C.

Cage — a machine for raising miners. See p. 30.

Cage—the barrel on which the rope is wound in a whim. See p. 11.

Cainozoic, 89.

Calamine, 100.

Calcination.—See *Burning*.

Calcium, 66.

Calc Spar, 102.

Cambrian, 93.

Cann, *Kann*, or *Kand*—fluor spar. See p. 101.

Capel—a very hard substance which often forms the sides of tin lodes. It frequently contains small quantities of tin ore.

Capstan, 53.

Carbon, 68.

Carbona—an irregular deposit of ore found in connection with some tin lodes in the west of Cornwall.

Carbonate, 71.

Carbonate of Copper, 97.

Carbonate of Iron. 99.

Carbonate of Lead, 98.

Carbonic Acid, 70.

Carbonic Oxide, 70.

Carboniferous, 92.

Casing—a wooden partition separating the footway from the other portions of a shaft.

Cassiterite, 97.

Caunter—a mineral lode whose direction crosses that of the main lodes of a district.

Chalcedony, 101.

Chalk, 86.

Chert—a hard flinty substance found in connection with some limestone and valuable for road-making.

China-clay—a white and pure kind of clay used in the manufacture of China. It is abundant in Cornwall and Devonshire.

China-stone—a white decomposed variety of granite much used for the finer kinds of pottery.

Chlorides, 71.

Chlorine, 68.

Chlorite, 104.

Choke-damp, 80.

Chromium, 66.

Claggy—sticky.

Clay Pits, 42.

Clay Iron—an instrument of iron used for lining bore-holes with clay to prevent the gunpowder from becoming wet.

Clay Slate, 110.

Cleat.—See *Joints*.

Cleavage—the property which many minerals and rocks possess of splitting more easily and perfectly in some directions than in others. In rocks the cleavage, when present, is usually much more distinct and perfect than the bedding.

Cleet—a wedge; also a strengthening piece of wood.

Coal, 106.

Coal-basin, 25.

Coal-measures, 92.

Coal-pipes—very thin layers of coal.

Cobalt, 66.

Cobbing, 14.

Cockle—the Cornish name for schorl or black Tourmaline.

Coffer, *Cofer*, or *Cover*—the box into which ore falls in order to be pulverised by the stamping mill.

Compounds, 63.

Concentration, 21.

Conglomerate—a rock made up of rounded pebbles.

Coper—one who contracts to raise lead ore at a fixed rate.

Copper, 66, 96.

Copper Pyrites, 97.

Copper Smelting, 75.

Core—the space of time during which miners remain underground at their work. In Cornwall this is usually eight hours. In many mines the men are divided into three parties, each working eight hours, so that the work is carried on uninterruptedly.

Corve or *Corf*—a square frame of wood for carrying or sliding coal or ore upon at the bottom of the mine. Sometimes called a "dan."

Costeaning—searching for ore by sinking shallow pits in likely places, and driving short galleries, or cross-cuts, from one to another.

Count-house.—See *Account-house*.

Country.—The rocks in which a lode may occur are in Cornwall called the "country."

Course—a vein. Thus men speak of a "course of ore," an elvan "course," &c.

Crab—a machine used for raising weights.

Crane — a machine for raising heavy weights. See p. 40.

Creep—the raising of the floor of a coal mine after the coal is removed, from the weight of the rocks above forcing the pillars left for support down into those below.

Cretaceous, 89.

Crib—the foundation of the lining or tubbing of a shaft. Newcastle term.

Crib or *Curb*—a frame of wood forming the foundation of the lining or tubbing of a shaft.

Cropping out—the appearance of a lode or bed at the surface of the earth.

Crop-tin—the chief portion of the tin ore, which is separated from its waste in the principal dressing operations. The finer portions, which are carried away by the water, are called "slime;" and that which is too coarse is called "rows" or "roughs."

Cross-course—any vein consisting principally of quartz, whose direction is across that of the lodes in a given district.

Cross-cut — in metal mining, a gallery or level driven across the usual direction of the lodes, usually for the purpose of searching for a new lode or of connecting two known lodes. In coal mining, any passage driven at an angle with the "face" of the coal.

Crowbar—a strong bar of iron much used as a lever in quarries and other places for moving heavy masses.

Crushing, 14.

Culm, 76.

Cupel — an instrument made of bone-ash, used in the separation of silver from lead.

Cupreous—containing copper.

Cut.—To intersect a lode is called cutting the lode.

Cutter.—See *Joints*.

Cylinder, 61.

D.

Damp—a miner's term for foul air. See *Fire-damp* and *After-damp*.

Dan.—See *Corve*.

Davy or *Davy Lamp*—the safety-lamp invented by Sir H. Davy.

Dead Ground—a portion of the lode containing little or no ore.

Deads.—See *Attle*.

Derrick—a pulley for raising a kibble from small depths in which the horse simply walks forward.

Devonian Rocks, 92.

Dial—a kind of compass used for taking bearings underground.

Dialling—the art of surveying by means of the instrument called the miner's dial.

Diamond, 106.

Diamond fields, 37, 43

Diamond gravels, 37.

Dip—the amount of slope of a bed or vein measured from a horizontal line. See *Underlie*.

Direction.—The point of the compass towards which any vein or lode tends is its direction. In Cornwall most of the copper and tin lodes have a direction not far from east and west, but varying somewhat in different parts of the county.

Dirt, 35.

Disintegrate—to break up from the effect of decomposition.

Disseminated—sown or sprinkled. Minerals which occur in small particles throughout the mass of a rock are said to be disseminated. Thus tin ore is often found disseminated in granite.

Distillation, 74.

Dole—a division, as one-sixth, one-eight, and the like, of a parcel of ore.

Dolomite, 104.

Downcast—the downward current of air in a coal mine.

Drainage, 5.

Dredge—very fine matter held in suspension in water.

Dresser—the person who undertakes the dressing of ores.

Dressing of Ores—the act of separating ores from waste matter and preparing them for sale.

Drift—any working underground which is horizontal or nearly horizontal.

Driving — digging horizontally, either along or across the course of the lode.

Dropper—a branch or string which leaves the main lode on the foot-wall side.

Drum—a kind of cage upon which chains or wire ropes are wound.

Dry—a place fitted with warming apparatus for drying the miners' underground clothes.

Dues—the portion of the produce of a mine which is paid to the land-owner or lord of a mine in lieu of rent.

Duff—the small coal after the "nuts" have been separated.

Duty of Steam Engines — the amount of work done by any engine by the consumption of 1 cwt. of coal. This duty is generally reckoned in "foot-lbs." or lbs. weight raised one foot high. In many good pumping engines more than 60,000,000 lbs. of water are raised 1 foot high by the consumption of each cwt. of coal.

Dyke—a course or vein of igneous rock

Dyke—a fault. Newcastle.

E.

Elements, 63.

Elvan — The Cornish name for veins or courses of a kind of porphyry which sometimes extends through the country in the manner of a lode for many miles. See p. 108.

End—The extreme point of any level, at which the men must work in extending it further.

End of Coal.—See *Joint.*

Engine Shaft—the shaft by which the drainage water of the mine is raised up to the adit or surface.

Eocene Rocks. 88.

Equivalents, 70.

F.

Face.—See *Joint.*

Fathom—6 feet. In metal mines all distances are reckoned in fathoms.

Fault—a disturbance of the strata, as shown in Fig. 3, *l l*, p. 5. When the displacement is horizontal, it is usually called a *heave* by miners; if upwards, a *leap* or *upthrow;* if downwards, a *slide* or *down-throw.*

Feather—an instrument used in wedging off masses of rocks. See *Plug and Feather.*

Feeder—a branch, when it falls into the lode.

Feigh — the refuse wasted from lead ore or coal.

Felspar, 102.

Ferruginous—containing iron.

Filler — the man who fills the kibble, or skip, with ore at the bottom of a mine.

Fire-damp — the explosive gas which escapes from the coal in many coal mines, and often fills the old workings. See p. 79.

Fissure—a crack. Most geologists consider that lodes are simply fissures, originally formed by earthquakes or other causes, but now more or less completely filled with ores and veinstones.

Flat Rods—pump rods arranged to work horizontally or nearly so.

It sometimes happens that an engine placed over one shaft of a mine is required to work the pumps which extend down another shaft at a considerable distance. In such cases the connection is made by means of horizontal pump-rods or "flat rods," running upon rollers to lessen friction.

Flint—a variety of the mineral quartz, which is abundant in chalk rocks.

Flookan or *Flucan*—a cross-vein which is filled with clayey matter. Flookans which run parallel with the lode are sometimes called "course-flookans."

Flues, 22, 74.

Fluor, 101.

Fluorine, 69.

Flux—anything added to an ore so as to render it more readily fusible. See p. 73.

Foot-wall.—See *Walls of a Lode.*

Footway—The series of ladders and sollars by which men enter or leave a mine. They are sometimes called "waygates" or "climbing shafts" in the North of England.

Force, 44.

Fork—in Cornwall, the bottom of the sump, which see.

Fork—in Derbyshire, a piece of wood used to keep up the side of an excavation in soft ground.

Fossils, 85.

Foundershaft—the first shaft sunk in a mine.

Frame—an inclined board over which a gentle stream of water is made to flow, for the purpose of washing away the waste from small portions of ore which are placed upon it from time to time.

Freestone—any kind of compact stone which may be worked freely. In some cases sandstones are called freestones, but more properly the name should be restricted to such soft stones as Bath-stone, Painswick-stone, &c.

Friable—anything that may be very easily reduced to powder.

Friction, 45.

Fuse—a kind of combustible cord used for firing powder in blasting.

Fuse—to melt. Substances which may be readily melted are said to be fusible.

G.

Gad—a kind of wedge used in breaking down small masses of rock in mining.

Galena—the most common ore of lead. See p. 98.

Gallery—a level of a mine.

Gangue—the valueless material, or "veinstuff," in which the ores of metals occur, or with which they are often mixed.

Gas, 44.

Gate—a road or way underground.

Gin—a machine for raising coal or ore from a mine.

Girdle—a thin layer of stone. Newcastle term.

Gneiss—a foliated rock composed of quartz, felspar, and mica. It differs from granite in these minerals occurring in distinct layers. See p. 108.

Goaf or *Gob*—the old deserted workings of a mine, often filled up with rubbish. In coal mines the goaf often contains a dangerous accumulation of gas.

Gold, 33, 66, 100.

Gold Gravels, 33.

Gossan—the upper decomposed portion of a lode. It usually consists of a mixture of cellular quartz and oxide of iron, and often extends to great depths in copper lodes.

Grain Tin—the purest kind of metallic tin.

Granite—a crystalline rock com

posed of quartz, felspar, and mica. See p. 108.
Graphite, 106.
Grass — the surface of a metal mine. Thus miners are said to "come to grass," when they come up from underground.
Grate—an iron plate punched full of small holes through which the stamped ore passes from the coffer to the dressing apparatus.
Gravel—small waterworn stones.
Great Adit, 7.
Green Copper Ore. See *Malachite*, p. 97.
Greenstone, 109.
Grey Ore—a very valuable ore of copper. See p. 96.
Growan—a kind of coarse sand produced by the decomposition of granite rocks. Lumps of granite are sometimes called hard growan.
Guides, 12.
Guides—a local name for certain cross veins in the west of Cornwall.
Gunnies—levels or workings.
Gypsum, 103.

H.

Hack—a large pick used for working stone.
Hade, *Hadeslope*—the underlie or inclination of a lode.
Halvans — the refuse heaps of mines, which still contain a small portion of ore, the residue of the dressing processes.
Hanging Wall—See *Wall of a Lode*.
Hauling—raising ore or waste out of the mine.
Header—See *Joints*.
Heading—A small gallery driven in advance of a gate road, or for any temporary purpose.
Heave.—See *Fault*.
Heavy Spar, 104.
Hematite — Red hematite and brown hematite are valuable ores of iron. See p. 98.
Hewer—a man who cuts or works coal.
Hitch—a small fault which does not exceed the height of the coal seam. See *Fault*.
Hole—To hole is to make a communication from one part of a mine to another. Thus a level is sometimes driven at the same time from two shafts so as to meet or hole at a point between the two.
Homogeneous—of equal composition throughout, applied to minerals.
Horn—a line running at an angle of 45° with the face of the coal.
Hornblende, 103.
Hornblende Rock, 110.
Horse—any piece of "country" included within a wide lode; or two branches of a lode is called by metal miners a "horse" or "horse of ground."
Horse-gin, 30.
Horse-whim, 11.
Huel or *Wheal*—the Cornish name for a mine.
Huronian Rocks, 93.
Hydraulic Mining, 35.
Hydrochloric Acid, 70.
Hydrogen, 69.
Hydrous or *Hydrated*—containing water.

I.

Igneous, 83.
Inclined Plane, 57.
Indurated—hardened.
Inertia, 45.
Infusible—anything which cannot be "fused" or melted.
Iodine, 69.
Irestone or *Ironstone*—a Cornish term for greenstone, given on account of its extreme toughness.
Iron, 66, 98.
Iron Smelting, 78.

J.

Jack—a miner's term for zinc blende.

Judding Pick—an instrument used for cutting long and deep grooves for the purpose of detaching large blocks of stone.

Jigging—a method of dressing poor copper and lead ores by shaking them with a peculiar motion in a kind of sieve which is made to move up and down in water. See p. 18.

Joints—natural divisions in masses of rock. They are variously called backs, cutters, faces, cleats, ends, &c., according to their relative positions, the locality, and the material in which they occur. See p. 39.

Judd—a portion of coal ready to fall, excavated all round.

Judge—a staff used for underground measurements.

Jumper—a tool used in quarries for the purpose of boring holes for blasting. See p. 40.

Junction—the point at which two veins meet.

Junking—a passage through a "pillar" of coal.

K.

Kann or *Cann*—a Cornish miner's term for fluor spar.

Keeker—an overlooker.

Keel—a large boat used for carrying coals.

Kevil—a sparry substance found in the Derbyshire lead veins. composed of calcite, fluor, or barytes.

Kibble—a kind of iron bucket used in many metal mines for raising ores. See p. 12.

Kieve—a large tub of wood or iron used for tozing tin ore before selling. See p. 17.

Killas—a Cornish miner's term for all kinds of slaty rocks.

Kit—a wooden vessel.

Knots—small particles of ore.

L.

Lander—the man who receives the loaded kibble or skip at the mouth of the shaft.

Launder—a gutter of wood or metal used for conveying small streams of water from place to place.

Laurentian Rocks, 93.

Lava, 109.

Lead, 66, 98.

Leader—a branch of ore which if followed up often leads to the main lode with which it is connected.

Leadings—small sparry veins in the rock. A Derbyshire term.

Leap.—See *Fault.*

Leat—a water-course.

Leavings—waste heaps resulting from the dressing of ores.

Levels—galleries driven along the lode, in Cornwall usually at depths of ten fathoms below each other.

Lever, 48.

Lewis—an instrument of iron used for raising heavy blocks of stone.

Lias Rocks, 91.

Lifters—the upright beams to which the heavy stamp-heads are attached for stamping ores.

Limestone—any stone consisting chiefly of carbonate of lime. See p. 85.

Limp—an instrument of iron used for striking the refuse from the sieve in washing ores.

Liquid, 44.

Loading Pick—a pick made specially for breaking large lumps of coal, so as to make them more convenient for loading on the corve, sometimes called a "hoper."

Loch—a cavity in a vein. Derbshire term.

Lode—a vein of any metallic ore. See p. 3.
Longwall System, 28.
Lord—the owner of the land in which a mine is situated is called the "lord." He receives generally a portion of the produce of the mine, in lieu of rent. This is called the "lord's due." It is frequently one-fifteenth of the produce of the mine in Cornwall.

M.

Magnesite, 105.
Magnesium, 66.
Magnetic Iron Ore. See *Magnetite*, p. 99.
Magnetite, 99.
Malachite, 97.
Mallet — the hammer used in striking or "beating" the borer.
Man-engine—a machine used for raising and lowering miners. See p. 22.
Manganese—67, 100.
Material Man—the man who has charge of and deals out the materials.
Matrix—the substance in which any portion of ore occurs embedded.
Matter, 44.
Mattock.—See *Pick*.
Maul—a large hammer or mallet.
Mear—32 yards of ground measured on the vein.
Mercury, 67.
Mesozoic Rocks, 91.
Metalliferous—containing or yielding metal or ore.
Metalloids, 72.
Metallurgy—the art of extracting metals from their ores. See p. 73.
Metals, 72.
Metamorphic Rocks, 107.
Mica, 102.
Mica-schist, 102, 109.
Micaceous—containing mica, or occurring in thin scales like mica.
Millstone Grit, 92.
Mineralised—containing particles of some "metallic" mineral.
Mineralogy, 95.
Mines, 1.
Miocene Rocks, 88.
Mispickel, 99.
Mixtures, 64.
Mock Lead—blende.
Moorstone—loose masses of granite which are found lying upon the moors in Cornwall.
Mundic—the Cornish and Devonshire term for iron pyrites.
Mundic (White).—See *Mispickel*.

N.

Native Copper, 96.
Needle—a piece of stout iron wire used to make a hole through the tamping of a hole down to the gunpowder, to serve as a touch-hole. It is called a pricker in many places.
Nickel, 67.
Nip—a sudden thinning of a seam of coal.
Nitrate of Soda, 105.
Nitrogen, 69.
Noger—a jumper, borer, or drill.
Nogs — square blocks of wood which are piled one upon another to support the roof of a coal mine.
Noper.—See *Loading Pick*.
Nuts—small coal.

O.

Ochre.—Earthy ores of iron are called ochres. They are generally red, yellow, or brown.
Old Men—the persons who worked a mine at any former period of which no record remains.
Old Men's Workings—workings made by the "old men," some-

times themselves called old men.

Oolitic Rocks, 90.

Open Cut—an open cutting.

Opens—large caverns.

Ore—any natural substance which is worked for the metal it contains. See pp. 2, 96.

Outcrop.—See *Cropping Out.*

Overburden.—See *Burden.*

Overburden, 38.

Overman—an overlooker.

Overwinding, 31.

Owner's Account Men—men paid at a fixed rate per day.

Oxide—Any element which combined with the gas oxygen forms an oxide. See p. 70.

Oxygen, 69.

Ozokerite, 106.

P.

Packing—See *Tozing.*

Pair or *Pare*—a party of miners who agree to work in partnership together. A pair of men usually consists of more than two and often of ten or twelve men

Palæozoic Rocks, 93.

Parcel—a heap of ore dressed and ready for sale.

Pass—an opening left for letting down ore and deads to any level.

Pay-dirt, 36.

Peach—the Cornish miners' term for chlorite.

Permian Rocks, 91.

Phosphorus, 69.

Phosphorite, 105.

Pick or *Pike*—slitter, mattock, pike-hake.

Pillar—an upright piece of a lode left to support its walls.

Pillar and Stall—See *Post and Stall.*

Pipe-vein—a vein of ore which is bounded above and below, as well as on both sides, by the "country."

Piston, 61.

Pit—a coal mine.

Pitch—limit of the ground set to tributers or tut-work men, 24.

Pitman—one who works in a coal mine.

Pitman—one who has to look after the pumps and drainage of a mine. In Derbyshire, any underground worker.

Pitwork—the pumps and other appliances in the shaft.

Platinum, 67.

Pliocene Rocks, 88.

Plug and Feather—Instruments used in wedging off small masses of rock.

Plumb—soft.

Plumb—perpendicular or upright.

Plump—a Cornish term for a well.

Plutonic Rocks—such rocks as are believed to have been formed deep down in the earth. Granite and porphyry or elvan are Plutonic rocks. See p. 107.

Pocket.—See *Bunch.*

Podar—anything that is brittle or worthless. The term is now applied to mundic, but yellow ore was formerly called podar when occurring in tin ores, as it reduced the value of the tin.

Point of Horse—the point at which a lode divides into two.

Porous—containing minute pores or holes.

Porphyry—any rock in which distinct crystals of any kind are embedded in a non-crystallised mass. The elvans of Cornwall are porphyries.

Post and Stall. 28.

Post-tertiary Rocks, 88.

Potassium, 67.

Power, 47.

Prian or *Pryan*—a soft clayey substance found in lodes.

Pricker—an instrument employed for making a communication through the tamping to the powder in a bore hole for the purpose of introducing a fuse or train.

Prill—a solid piece of pure metal from an assay. To "prill" a sample is to add some richer substance to it so as to obtain a false return.
Primary Rocks, 93.
Pulley, 54.
Pulp, 20.
Pulveriser.—A machine for *grinding* ores instead of *stamping* them is now often so called.
Pumice, 109.
Punch—a timber support for the roof of a mine.
Purple Copper Ore, 97.
Purser—the person who is responsible for the accounts and pays the men in a mine. He is both treasurer and secretary.
Putter—one who conveys the coal from the working to the horseway, or the bottom of shaft.
Putting Coal, 30.
Pyrites, 99.
Pyritous—containing pyrites.
Pyrolusite, 100.

Q.

Quarries, 1.
Quartz—a very abundant hard mineral substance. See p. 101.
Quartz Rock, 109.
Quartzose—containing or consisting chiefly of quartz.

R.

Racks—a kind of frames for dressing tin ores.
Ramble—refuse coal lying at the top of the seam.
Red Copper Ore, 96.
Red Hematite, 98.
Reduction of Ores—the extraction of the contained metal.
Reserves, 8.
Resistance, 47.
Rib—a pillar of coal left to support the roof.
Riddle—a sieve.
Riddling—sifting.
Rider—a mass of rock dividing a vein. See *Horse.*
Ringer—a crowbar.
Rise—to work upwards towards the surface.
Road Metal—any stone which is used for mending roads.
Roasting.—See *Burning.*
Rocks, 82.
Rock-salt, 104.
Rod—The upright beam of a man-engine.
Roof—the part of a mine or level above the miner's head. In Cornwall called the "back."
Roughs or *Rows.*—See *Crop-tin.*
Round Coal—large pieces of coal.
Run.—When the parts of a mine or excavation fall together, they are said to "run."
Run of a Vein.—See *Direction.*

S.

Safety-fuse, 9.
Safety-lamp, 80.
Sampler—the person who takes the samples of ores for assaying, or determining their value.
Sandstone, 86, 101.
Schorl, 104.
Schorl Rock, 109.
Scraper—an instrument for extracting the dust or rubbish from holes while boring.
Screw, 59.
Scrin—a small vein. Derbyshire term.
Seam.—A bed of coal or iron ore is often so called.
Seat or *Sole*—the floor or bottom of a mine or level.
Secondary Rocks, 91.
Sedimentary Rocks, 83.
Serpentine, 103, 109.
Set—to set or make an agreement with miners for the execution of any piece of work. See *Bargain.*
Sett—the tract of land in which a mine is situated.

Setting-day—the day set apart once a month for making bargains with miners for the future working of a mine.
Shaft—a deep pit. All the deep pits in a mine sunk down *from the surface* are called shafts.
Shaft Pillar, 26.
Shake—a fissure in the earth.
Shak—a quarryman's term for a crack in a block of stone.
Shift.—See *Core*.
Shode—to trace the position of a lode by observing the scattered loose stones from its upper part or "back."
Shots, 10.
Show—a pale blue tip to candle-flame indicating fire-damp.
Shutting or *Shooting*—blasting.
Silicates, 71.
Silicon, 69.
Silurian rocks, 93.
Silver, 67, 100.
Sink—any excavation in a downward direction.
Sinking—digging downwards.
Sinking a shaft, 6.
Skep.—See *Skip*.
Skimpings—the upper layer of impure tin ore, which is scraped off from that which has settled in a kieve. It is taken off and dressed over again by itself.
Skip—a kind of carriage in which ore is raised from the bottom of the mine, sometimes called a "skep." See p. 12.
Slag—a waste product formed in smelting ores. See p. 73.
Slate—a kind of rock which splits readily into thin layers.
Sled—a sledge without wheels. See *Corve*.
Slide.—See *Fault*.
Slimes—fine mud containing particles of tin. See *Crop-tin*.
Slipes—Flat pieces of iron for the corves to slide upon.
Slitter.—See *Pick*.
Sludger—an instrument for removing the mixture of dust and water, or "sludge," from bore holes.
Slyne.—See *Joints*.
Smalls—small coal or ore.
Smelting—extracting metals from their ores. See pp. 19, 73.
Smitham—small dust of lead ore.
Smut—decomposed or dusty coal.
Sodium, 67.
Soil, 82.
Sollar—a small platform at the foot of a ladder in the shaft. See p. 23.
Sough—an adit.
Spale—a fine. For absenting himself from the mine without leave, or for breaking any of the rules of a mine, a man is liable to be fined or "spaled."
Spall, *Spalling*—breaking large stones of ore to a smaller size, so as more readily to pick out the barren, stony parts. See p. 13.
Spar—a Cornish miner's name for quartz.
Spar—a Derbyshire name for fluor.
Spars, 101.
Spathose Iron, 99.
Specific Gravity, 70.
Spel—a change or turn. Thus, if several men have to do a piece of heavy work upon which all cannot work at once, they change about, each taking a spel.
Spreaders—pieces of timber placed across a shaft which seems likely to fall in, to serve as a temporary support until it can be properly timbered.
Stamping—the breaking of ores into fine particles, in order that thay may be dressed for sale.
Stamps—contrivances for stamping ores. See p. 15.
Stamps-head—the block of iron which forms the lower part of the stamps.
Standard—the price of metallic copper or tin.
Stem—a day's work.
Stemple—a strong beam pl

in a slanting position, so as to support the walls of a lode.

Stemples—pieces of iron or wood fixed into the sides of a shaft to serve instead of ladders.

Stickings—narrow veins of ore.

Stock-works, 42.

Stone-axe—a tool used in dressing the surface of blocks of stone.

Stopers, 9.

Stow—to pack away.

Stowce—a windlass.

Stowces—pieces of wood used to indicate possession of any part of a mine.

Stratified Rocks, 83.

Streamers—Persons who work in streams in search for stream tin.

Stream Tin—that kind of tin ore which is obtained from stream-works. It is the most valuable kind of ore, and yields the purest tin.

Strik, or *Streek*—to let a man down a shaft by means of a windlass.

Strike—the direction of the outcrop of a bed of rock in a level country, or a line at right angles to its dip.

Strings—thin veins of ore in connection with a lode.

Stuff—the material raised from the mine, whether ore or deads.

Stull—timbers placed in the backs or upper parts of levels, and covered with poles or boards, to support the walls, or rubbish which it is not desired to bring to surface.

Sturt.—A tribute bargain which turns out extraordinarily well for the miner is called a sturt.

Sulphides, 71.

Sulphur, 69, 105.

Sump—the bottom of the engine shaft, which is usually sunk below the deepest level, so as to form a pit in which the waters may collect before being pumped up.

Sumpmen—men who assist the pitmen to keep the sumps clear.

Sump-shaft—the engine-shaft.

Swabstick—an instrument for removing dust and mud from bore-holes.

Swallow—a cavern or opening into which water falls, and is lost sight of.

Syenite, 108.

Symbols, 71.

T.

Tackle—The ropes, chains, kibbles, and other arrangements for raising ore, &c., in connection with any shaft.

Tacklers — small chains to put round loaded corves to keep the coal or ore from falling off.

Tails—the roughest of the refuse tin, which is often stamped over again.

Tamping—the stuffing up of a bore-hole above the gunpowder, so as to secure a more effective blast. See p. 10.

Tamping—the material used in the above operation.

Tamping Arrow—a long and thin piece of metal used for making a communication through the tamping of a bore-hole with the powder at the bottom.

Tamping Bar—a bar used in driving in the tamping material in tamping a hole.

Tertiary Rocks, 89.

Thill—the floor of a mine.

Threads.—See *Strings.*

Throw.—See *Fault.*

Thrust—the falling in of a mine after supports are removed.

Thurst.—See *Thrust.*

Ticketings—the weekly meetings for the sale of ores.

Tie.—See *Tye.*

Tile Ore—a valuable ore of copper. A variety of Red Copper ore.

Timbering.—The fixing of timber

in a mine to support the sides of shafts, or the walls and roofs of levels is called timbering. See p. 27.
Timber-man—one whose duty it is to see to the timbering of a mine.
Tin, 68, 97.
Tin Gravels, 36.
Tin Smelting, 76.
Tinner—tin miner.
Tin-stone—the ordinary ore of tin, often called cassiterite. See p. 97.
Toadstone—a name used in the middle and north of England for the masses of basaltic rock which are often found forced up through the coal measures.
Tozing—the last operation in tin-dressing. The nearly clean ore is violently stirred up in a kieve with water, and then allowed to settle, while a continual knocking is kept up against the sides of the kieve. See p. 17.
Trachyte, 109.
Tramway, Tram—a railway suited for the passage of waggon-loads of ore or coal. See p. 10.
Trap—a general term often applied to all the various kinds of greenstone and basalt.
Trias, Triassic Rocks, 91.
Tributer—one who works upon tribute. See p. 8.
Trouble.—See *Fault.*
Trunk—a long narrow pit into which the slimes are directed, so that the ore may subside.
Tubbing—the lining of timber or iron which is often applied in order to secure the sides of a shaft. See p. 26.
Tut-worker—one who works upon tut-work. See p. 8.
Tye—a long narrow channel leading directly from the stamps, in which the stamped tin ore is often partially dressed.
Tying—washing.

U.

Underlie—the amount of slope of a lode or vein, measured from the perpendicular. It is the same as the "dip" of a bed, only that the dip is measured from the horizontal.
Unit Weights, 72.
Unstratified Rocks, 83.
Upcast—the ascending air current from a coal mine.
Uphill—See *Bord.*

V.

Vanning—the art of separating ores from veinstuff by washing on a shovel.
Vein—a lode.
Veinstone, or *Veinstuff*. — See *Gangue.*
Ventilation—the art of removing foul or spent air, and of supplying pure and fresh air in its place, See p. 79.
Viewer—a superintendent.
Volcanic Rocks, 107.
Vugh—a cavity in a rock. A Cornish term.

W.

Wall of a Lode—the side where it comes in contact with the surrounding country. In Fig. 1, p. 3, the lode *a b underlies* to the left; the upper or left side is called the *hanging*, and the lower or right side the *fort*, wall.
Wastrel—any waste material.
Water-wheel—a wheel made to turn by a stream of water.
Wedge, 59.
Wheal—the Cornish name for a mine, often and more properly spelt *huel.*
Whim.—See p. 11.
Whin—any very hard stone.
Whinstone—trap.

White Mundic, Mispickel, 99.
White Tin—metallic tin.
White—tin ore partially dressed.
Winding Engine—an engine used for drawing up ore. See p. 12.
Windlass—a machine used for raising weights. See p. 11.
Winds, or Winze—A shaft which only communicates between two or several levels, but does not come to surface. See p. 7.
Wire Rope, 13.
Work—the ore or other stuff which is raised from a mine. Thus, miners speak of rich work and poor work.

Y.

Yellow Ore—the miners' name for copper pyrites or chalcopyrite, the most common ore of copper. See p. 97.
Yokings.—See *Stowces*.

Z.

Zinc, 68, 100.

THE END.

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